THE TELEGRAPHIC JOURNAL AND

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THE NEED.

FROM the widespread interest manifested in the discussion which has been taking place in the technical papers during the past few weeks upon the proposal to form an electrical association, it is evident that the views to which our contemporaries and ourselves have given utterance are, where they are broad and general, shared by most members of the electrical fraternity, and it is reasonable to expect that some decisive steps will quickly be taken to supply what has been termed a need of the age. We must utter a warning, however, against too hasty action. It is necessary to consider well what will most satisfactorily suit present requirements, and at the same time admit of suitable extension with the development which undoubtedly awaits electrical industries in the near future. We have suggested a modification of the methods of the Society of Telegraph Engineers and Electricians. To this it has been answered that what is required is an association which shall not trench at all upon the province of that society or of any other existing institution. It seems to us that in the present condition of electrical affairs the field will be a very limited one for the new association if it is to hold as sacred, and not to be disturbed, ground which has already been broken and partially cultivated by older societies. A specific and distinctive association for the treatment of one branch of electrical manufacture or application, corresponding precisely with the National Electric Light Association of America, or an annual meeting for one specific purpose like the Telephone Convention held on the other side, may be amongst the things of the future, but in this country to-day the interests are almost infinitesimally small compared with the corresponding interests in America which have given rise to those excellent annual gatherings to which we have alluded; and what is more particularly wanted is combination rather than detachment. We adhere to our view that the Society of Telegraph Engineers and Electricians could, if it chose, fill the gap which is generally felt to exist. The article which appeared in *Industries* last week bears an air of inportance and authority, and may seem very convincing to those who accept unquestioning the statements which it contains. The truth is, however, that in some essential particulars the writer is utterly at fault. It is not the fact that over 80 per cent. of the members of the Society of Telegraph Engineers are neither directly nor indirectly interested in questions concerning electric lighting or the transmission of energy. If it were, it would augur but ill for the success of a new association comprised of the other 20 per cent. only. Many of the members of the society who were at one time telegraph engineers and manufacturers solely, and who may have been set down by our contemporary as telegraph men pure and simple, have within the last few years taken up the allied industries of electric lighting and transmission of power in a manner which makes it absurd to say that, in the councils of the society, they would figure as sticklers for telegraph subjects to the partial exclusion of the claims of the newer branches. It is not a fair or accurate assertion, either, to suggest that undue prominence has been given to matters connected with telegraphy by the society. During the past two years almost all the papers read have been upon topics more nearly allied to electric lighting. It may be that even this has not been entirely satisfactory—that the fortnightly meetings of the society during a small part of the year may not afford sufficient opportunity for exhaustive discussions, and one way of remedying this difficulty is to hold the meetings weekly instead of fortnightly. If a generally supported representation be made to the committee, the members of which are fairly representative of the industries which some of our contemporaries seem to think are shut out in the cold, we feel assured that the proposition would be favourably considered. Another suggestion which we would make to the council of the society is that invitations to specialists to prepare papers should be issued, and that premiums should be granted in special cases. The leading electrical firms would doubtless assist in promoting some scheme to render this latter course possible.

To meet the desire for a summer session, we have suggested that efforts should be made to form a sub-section of Section G of the British Association. This would undoubtedly be the most economical plan. At present many electrical engineers attend the British Association meetings for the purpose of hearing or taking part in discussions upon subjects which interest them. The opportunities for discussion are, under existing arrangements, limited; but with the formation of a sub-section to themselves, provided due care were observed to prevent over-crowding (not so likely to occur in a restricted sub-section as in the section itself), members of the profession would have themselves only, or at the worst each other, to blame if they held their tongues and left unsaid the many valuable things capable of being brought forward.

Now we come to the question of the proposed new Association. To be a success, this must be entirely independent of any existing society, and bear a title which shall make it obvious that the intention is to keep perfectly clear of the scope of those already established.

It has been suggested in more than one of our contemporaries that it should be formed on the lines of the Dynamicable Society, only more so. We can only think that the writers were poking fun at their readers when this suggestion was made. We are ourselves members of this community, and we have enjoyed several pleasant evenings during its sessions, but we have not yet considered the society from a more serious

point of view than that for which it was ostensibly and originally formed. As a matter of fact our candid opinion, after going through the correspondence which has appeared in our own pages, and with the additional advantage of having had placed at our disposal a number of private letters all bearing upon this all-absorbing topic, is that not one man in ten has the faintest idea of the purport of the scheme which it is his expressed intention to support so vigorously and enthusiastically, and which has secured his warm approval. It is certainly a curious trait in human nature that any new proposition, notwithstanding that no definite line of action has been broached, or a single meeting been held to discuss its chances either of success or even of desirability, finds numerous supporters; but when one analyses the contents of their letters it can be seen almost at a glance that the communications have been compiled on the spur of the moment and without any consideration of a contemplative kind. It has, moreover, been hinted at, that the Cable Companies might associate themselves with the new Society, but what earthly reason there can be for such a supposition is beyond our ken. We thought that all matters affecting submarine telegraphy were periodically discussed during international conventions, but perhaps we have not quite grasped the drift of the allusion to which we refer.

Another suggestion is that the Iron and Steel Institute should be taken as a model, because meetings such as those of this society would give members an opportunity of seeing the methods of procedure adopted by those in whose district the meeting is held, so that no matter what part of the country the association visits there would be something interesting for the practical man to see both in central station lighting and also in isolated installation work. Considering the smallness of our "tight little island," and how easy of access it is to all parts, and remembering the sloth-like progress of anything electrical in the United Kingdom, and how little there is to see, we do not think that there exists any need for a body of men to spend a week or so in any particular district to examine into an example of electric lighting or an electric locomotive, which could just as easily be thoroughly understood by taking a flying visit which need not entail more than a day's absence from one's headquarters. In America, of course, from the vastness of the country and the magnitude of the undertakings there carried into effect, the whole thing is very different.

Finally, if there is to spring into existence a new association, it seems to us that it must confine itself strictly to protection of trade interests in respect to legislation and the discussion of commercial matters, and to give opportunities for those engaged in the development of electrical industries to confer together on trade interests generally. Not more than three of the seventeen propositions which Mr. Rawson propounded in our last issue could satisfactorily be brought within the province of a body such as has been imaginarily formulated, as Mr. Garcke's letter of to-day to a certain extent shows. In fact, his communication puts the whole thing in a nut-shell, and this being so, we have only to add that if an association on some such lines as are there indicated finds a sufficient number of supporters to make it an important and representative gathering, and not a weak and tottering structure which would eventually fall to the ground overweighted with burdens with which it could not possibly cope, we should be amongst the first to accord it a hearty welcome.

If it can be satisfactorily shown that such an addition to the already numerous societies with which electrical men are more or less closely associated can confer any benefits upon them, and if an ultimate and lasting good will result therefrom, by all means let it be brought into life and fostered into strong and healthy activity. Anything to promote the struggling industry which we endeavour by the best means in our power to honestly represent we shall hail with satisfaction; but we must in this case, as in others, look before we leap.

PROFESSOR SILVANUS THOMPSON delivered a stirring address to the students of the Aldenham Institute at St. Pancras last Saturday. He presided over the gathering at which the annual distribution of prizes and certificates took place, and in a lengthy speech drew comparisons between the support extended to the movement for technical education in Continental countries, Germany especially, and in England, and condemned the system in vogue in our elementary schools whereby eleven out of the thirty school hours were absolutely wasted. He claimed that more attention should be given to bread and butter subjects, and to show that those subjects are overlooked, stated that from the eastern half of London every year ten thousand boys left the Board schools with no higher ambition than to become City clerks. Even for that vocation they were not fully equipped, for the School Board for London did not teach one of them shorthand, which he held to be the most essential accomplishment of a City clerk. As an Englishman he wanted to see England for the English, and therefore it was that he hailed with pleasure the opening of technical institutes in London and the provincial towns. Taking him all round, the Englishman had in him the making of a finer man than any other European, and the reason that the superior animal had become the inferior one was because our masters had been too busy worrying about politics to trouble about education. Prof. Thompson has a right to speak upon this subject, for he has taken a large share in the work of arousing public interest in the movement and public belief in its necessity. Something like ten years ago he wrote a pamphlet in which he pointed out that England was in danger of having her industries destroyed by other nations who saw a little more clearly what the prosperity of a commercial community depends upon. We trust that he is witnessing something of the first-fruits of his past labours in this beneficent direction, and that technical institutes and classes will increase and multiply as the time goes on.

CAN anyone inform us why the London Road Car Company has ceased to use "Eclipse" batteries and incandescent lamps for the lighting of its omnibuses? A great deal was at one time made of the adoption of the battery for lighting purposes by this company.

MODERN VIEWS OF ELECTRICITY.*

By PROF. OLIVER J. LODGE, in *Nature*.

PART I.—II.

FIRST you have an inextensible endless cord circulating over pulleys; this is to represent electricity flowing in a closed circuit. Electromotive forces are forces capable of moving the cord, and you may consider them applied either by a winch, or by a weight on the hook, W. A battery cell corresponds to a small weight; an electric machine to a slow but powerful winch. Clamping the cord with the screw, S, corresponds to making the resistance of the circuit infinite. Instead of the cord, clamp, and driving pulley, one

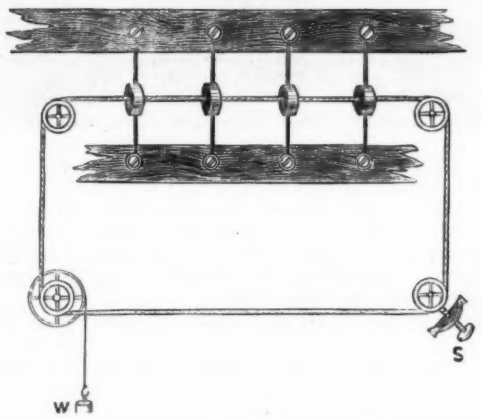


FIG. 5.
Mechanical analogy of a *metallic* circuit.

might consider an endless pipe full of liquid with a stop-cock and a pump on it, but for many purposes the cord is sufficient and more simple. In fig. 5, the only resistance to the motion is friction, and there is no tendency to spring back. Fixed beads are shown on the cord to typify atoms of matter, and they may be more or less rough to represent different specific resistances. If the cord be moved, heat is the only result.

Now pass to fig. 6. Here the cord is the same as

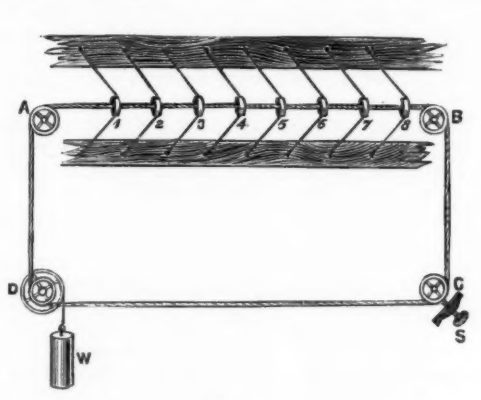


FIG. 6.
Mechanical analogy of a circuit partly *dielectric*; for instance, of a charged condenser. A is its positive coat, B its negative.

before but the beads are firmly attached to it, so that if it moves they must move with it. They represent, therefore, the particles of an insulating substance. Nevertheless, their supports are not rigid—they do not prevent the cord moving at all; they allow what is called electric "*displacement*," not conduction; they can be displaced a little from their natural position, but they spring back again when the disturbing E.M.F. is removed. The beads in this figure are supposed to be supported by elastic threads; if the cord were replaced by a closed pipe full of water they would be replaced by elastic partitions.

Apply a given E.M.F. to this cord and a definite displacement is produced. One side gets more cord than usual—it is positively charged; the other gets less—it is negatively charged. If the applied E.M.F. exceeds a certain limit the strain is too great. The elastics break, and you have disruptive discharge with a spark. But even when the strain is only moderate some of the supports may yield viscously, or be imperfectly elastic and permit a gradual extra displacement of the cord, known to telegraphists as "soaking in."

When discharge is now allowed, it will not at once be complete; a large portion of the displacement will be at once recovered, but the rest will gradually "soak out" and cause residual discharges.

If the dielectric is at all stratified in structure, so that some of the beads allow cord to slip through them —or yield more than others—then this residual charge effect will become very prominent.

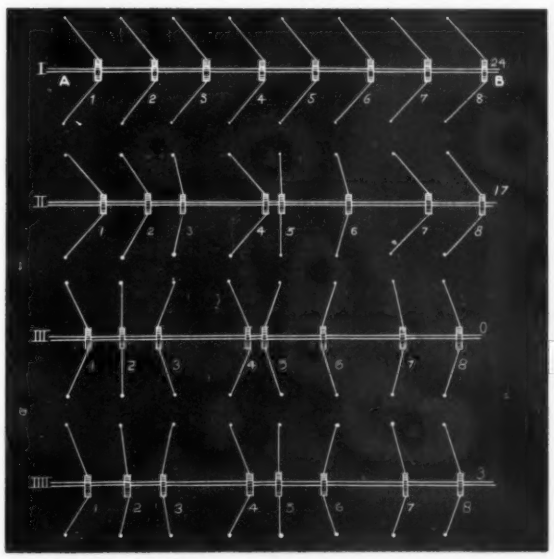


FIG. 7.
Stages in the discharge of a stratified condenser; showing one way in which the phenomena of "residual charge," "internal charge," and "soaking out" are produced.

Fig. 7 illustrates the various stages of a stratified dielectric, with layers of imperfect insulating power. I. represents a recent charge, of E.M.F. 24. II. represents the same after lapse of time, reduced to 17 by partial internal leakage; and shows internal charge. The circuit itself is supposed to have been perfectly insulating all the time. III. shows the first discharge; and IIII. shows the state attained after again waiting, viz., a residual charge with an E.M.F. 3 in the old direction.

Return, however, to the simple discharge, and see how it occurs. Will it take place as a simple sliding back of the beads to their old position? Yes, if the resistance of the circuit is great, but not otherwise. If the cord is fairly free the beads will fly past their mean position, over-shooting their mark, then rebound, and so, after many quick oscillations, will finally settle down in their natural position. Thus is represented the fact that the discharge of a Leyden jar is in general oscillatory; the apparently single and momentary spark, when analysed in a very rapidly rotating mirror, turning out to really consist of a series of alternating flashes rapidly succeeding one another, and all over in

* Expansion of a lecture delivered by Dr. Oliver Lodge, partly at the London Institution on January 1st, 1885, and partly at the Midland Institute, Birmingham, November 15th, 1886, but not hitherto published.

the hundred-thousandth of a second or thereabouts. These oscillatory currents were predicted and calculated beforehand by Sir William Thomson; they were first observed experimentally by Feddersen. The oscillations continue until the energy stored up in the strained medium has all rubbed itself down into heat.

Fig. 8 shows part of an actual model of the kind.

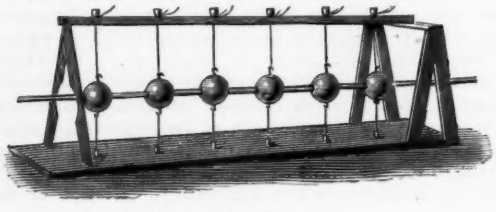


FIG. 8.

Partial model of a dielectric.

To make the model represent *charge by induction* all that has to be done is to immerse a conductor into the polarised dielectric—in other words, to make one or more of the beads of the fixed and slippery conducting kind, the other beads on the cord being of the elastic and adhesive or insulating kind. Then when the displacement occurs it is plain that a deficiency of cord will exist on one side of the metallic layer and a surplus on the other, as shown in fig. 9. This state of things corresponds exactly to the equal opposite induced charges on a conductor under induction, as in fig. 3. If the strain on one side be relieved by letting the beads on that side slip back on the cord: that corresponds to touching the conductor to earth, as in fig. 4. The other side has now to withstand the whole E.M.F., consequently the strain there and the charge there will have increased. Remove now the applied E.M.F., and the negative charge appears on both sides of the metal partition, either equally, or more markedly on that side which has fewest beads, *i.e.*, which is nearest to other conductors.

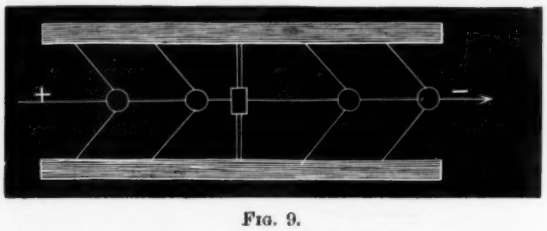


FIG. 9.

Metallic layer in the midst of a polarised dielectric, showing opposite charges "induced" on its surfaces. (Compare fig. 3.)

Hydraulic Model of a Leyden Jar.—So much for the cord model, but I will now describe and explain an hydraulic model which illustrates the same sort of facts: some of them more plainly and directly than the cord model. Moreover, since all charging is essentially analogous to that of a Leyden jar, let us take a Leyden jar and make its hydrostatic analogue at once.

The form of jar most convenient to think of is one supported horizontally on an insulating stand, with pith ball electroscopes supplied to both inner and outer coatings.

To construct its hydraulic model, procure a thin India-rubber bag, such as are distended with gas at toy-shops; tie it over the mouth of a tube with a stop-cock, A, and insert the tube by means of a cork into a three-necked globular glass vessel or "receiver," as shown in the diagram, fig. 10.

One of the other openings is to have another stop-cock tube, B; and the third opening is to be plugged with a cork as soon as the whole vessel, both inside and outside the bag, is completely full of water without air-bubbles.

This is the insulated Leyden jar: the bag represents the dielectric, and its inner and outer coatings are the spaces full of water.

Open gauge-tubes, *a* and *b*, must now be inserted in tubes A and B, to correspond to the electroscopes supplied to the jar; and a third bent tube, C, connecting the inner and outer coatings, will correspond to a discharger. Ordinarily, however, of course C will be shut.

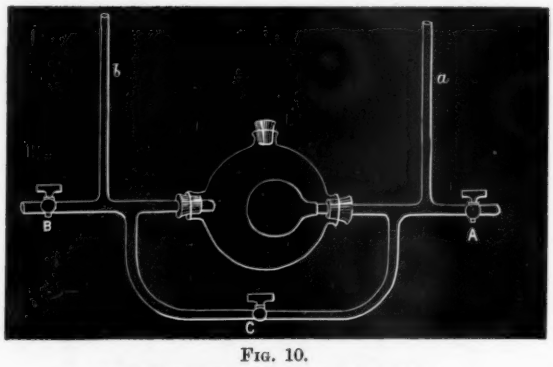


FIG. 10.

Skeleton diagram of hydraulic model of a Leyden jar.

A water-pump screwed on to A will represent an electric machine connected to inner coating; and the outer coating, B, should open into a tank, to represent the earth. The pump will naturally draw its supply of water from the same tank.

The bag being undistended, and the whole filled with water free from air, the level of the water in the two gauge-tubes will correspond with that in the tank; and this means that everything is at zero potential, *i.e.*, the potential of the earth.

Now, C being shut, shut also B, open A, and work the pump. Instantly the level in the two gauges rises greatly and equally: you are trying to charge an insulated jar. Turn an electric machine connected to a real jar, and its two pith balls will similarly and equally rise.

Now open B for an instant, the pressure is relieved, and both gauges at once fall, apparently both to zero. Repeat the whole operation several times, however, and it will be found that whereas *b* always falls to zero, *a* falls short of zero each time by a larger amount, and the bag is gradually becoming distended. This is *charge by alternate contact.* It may be repeated exactly with the real jar: a spark put in to the inner coating, and an equal spark withdrawn from the outer coating each time; and unless this outer spark is so withdrawn, the jar declines to charge: water (and electricity) being incompressible.

If B is left permanently open, the pump can be steadily worked, so as to distend the bag and raise the gauge, *a*, to its full height, *b* remaining at zero all the time, save for oscillatory disturbances.

Having got the jar charged, shut A, and remove the pump, connecting the end of A with the tank directly.

Now of course by the use of the discharger, C, the fluid can be transferred from inner to outer coat, the strain relieved, and the gauges equalised. But if this operation be performed while the jar is insulated, *i.e.* while A and B are both shut, the common level of the gauges after discharge is not zero, but a half-way level; and the effect of this is very noticeable if you touch an insulated Leyden jar after it has been discharged.

Instead of using the discharger, C, however, we can proceed to discharge by alternate contact, and the operation is very instructive.

Start with the gauge *b* at zero, and the gauge *a* at high pressure. Open stop cock, A; some water is squeezed out of inner coating, and the *a* gauge falls to zero, but the suck of the contracting bag on the outer coat pulls down the gauge *b* *below* zero, the descent of the two gauges being nearly equal.

Next shut A and open B; a little water flows in from the tank to still further relieve the strain of the bag, and both gauges rise; *b* to zero, *a* to something just short of its old position.

Now shut B and open A again; again the two gauges descend. Reverse the taps, and again they both rise; and so on until the bag has recovered its normal size. This is discharge by alternate contact, and exactly imitates the behaviour of an insulated charged Leyden jar whose inner and outer coats are alternately touched to earth. Its pith balls alternately rise with positive and with negative electricity, indicating potentials above and below zero.

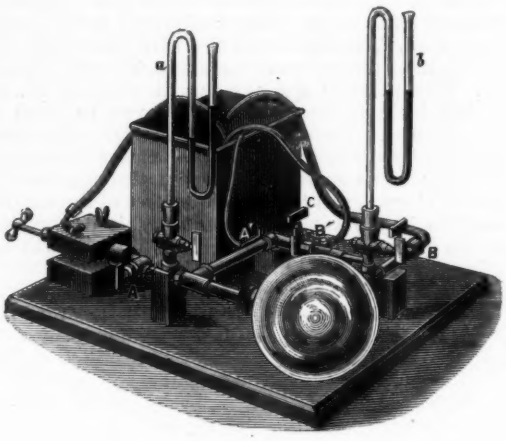


FIG. 11.

First actually constructed model Leyden jar, with mercury gauges for electrometers; the whole rigged up with things purchasable at a plumber's, except the pump.

Figs. 11 and 12 are taken from photographs of apparatus I have made to use as just described. The glass globe with the partially distended bag inside it, the pump, the tank, the gauges, *a* and *b*, the stop-cocks, A, B, C, will be easily recognised. Two extra stop-cocks, A′ and B′, leading direct to tank, are extra, and

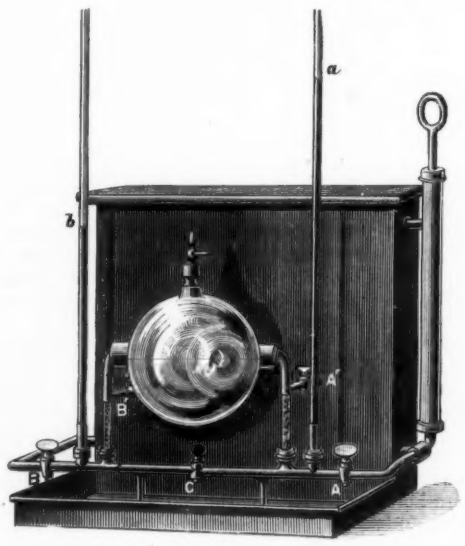


FIG. 12.

Latest form of hydraulic model of a Leyden jar with water gauges, the whole arranged vertically to be more conspicuous. The pump is a force pump with a communication between top of barrel and tank to get rid of stray water.

are to save having to disconnect pump and connect A direct, when exhibiting the effect of "discharge of alternate contact." But the tank is not sufficiently tall in fig. 12; I have doubled its height since. The full height of the gauge tubes is barely shown.

In any form of apparatus it is essential to fill the whole with water—pipes, globe, everything—before commencing to draw any moral from its behaviour. It is rather difficult to get rid of a large bubble of air from the top of the globe of fig. 11, and though it is not of very much consequence in this place, the stop-cock in fig. 12 is added to make its removal easy. The gauges in fig. 11 may be replaced by others arranged as a lantern slide, and connected by flexible tubing full of air.

I have explained thus fully the hydraulic illustration of Leyden jar phenomena, because these constitute the key to a great part of electrostatics. The illustration is not, indeed, a complete or perfect one by any means, but by combining with it a consideration of the endless cord models, and of what I have endeavoured to explain concerning conduction and insulation in general, a distinct step may be gained.

Think of electrical phenomena as produced by an all-permeating liquid embedded in a jelly; think of conductors as holes and pipes in this jelly, of an electrical machine as a pump, of charge as excess or defect, of attraction as due to strain, of discharge as bursting, of the discharge of a Leyden jar as a springing back or recoil oscillating till its energy has gone.

By thus thinking you will get a more real grasp of the subject and insight into the actual processes occurring in Nature—unknown though these may still strictly be—than if you employed the old ideas of action at a distance, or contented yourselves with no theory at all on which to link the facts. You will have made a step in the direction of the truth, but I must beg you to understand that it is only a step, that what modifications and additions will have to be made to it before it becomes a complete theory of electricity I am wholly unable to tell you. I am convinced that they will be many, but I am also convinced that it is unwise to drift along among a host of complicated phenomena without guide other than that afforded by hard and rigid mathematical equations.

The mathematical theory of potential and the like has insured safe and certain progress, and enables mathematicians to dispense for the time being with theories of electricity and with mental imagery. Few, however, are the minds strong enough thus to dispense with all but the most formal and severe of mental aids; and none, I believe, to whom some mental picture of the actual processes would not be a help if it were safely available.

Such a representation I have endeavoured partially to lay before you to-night, and I hope, if I have succeeded in making myself at all intelligible, that those students of electricity who may be present will find it of some use and service.

(To be continued.)

RECENT ADVANCES AND IMPROVEMENTS IN THE APPLICATION OF ELECTRICITY TO RAILWAY WORKING.

(*Continued from page* 135.)

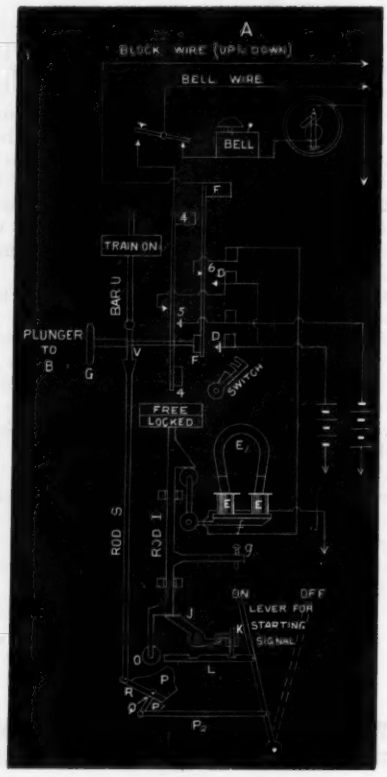
SYKE'S INTERLOCKING SYSTEM.

MR. SYKE'S first patent was taken out in February, 1875, and it was put into operation on the London, Chatham and Dover line shortly afterwards. Various improvements have been effected from time to time since that date, and it is now in operation at some 130 signal boxes on that line, several on the Metropolitan District line, throughout the new Hull and Barnsley line, and at some other few points in England. It has also been established in Russia and the United States.

At each intermediate signal box there are two block instruments, one for the up line, and one for the down line. Each section has also its bell, common to both up and down line, and which is provided with an

indicator in the shape of an arm, representing a miniature signal. The object of this semaphore arm is to show whether the section is "clear" or "blocked." The block instruments interlock with the signal levers. The bell is free except as to its battery current, which is regulated as to its character—whether positive or negative—by the combined action of the block instrument and signal lever. Rods connect the two latter, and it will thus be seen that it is desirable the instruments should be arranged directly over the signal levers.

To the lever which has to be interlocked is attached a slide bar or rod, I, having a notch, as shown, into which when the lever is standing in its normal position, that is, at "on," the lock, K, drops, thus preventing the lever from being pulled off. To enable the locking piece to be lifted out of the notch, it is provided with a lug with which the cross head, or rocker, J, engages so that on the left hand end of the rocker being depressed, the lock is lifted clear of the notch. The extreme end of the rod, I, is a small roller, O, moving on a peculiarly shaped cam, P; this rod, I, is



connected to the block instrument above. The cam, P, rotates around the centre, Q, and forms part of the piece, R, which by means of the rods, P^1 and P^2, receives its motion from the lower part of the signal lever. To R is attached a rod, S, which connects with that portion of the block instrument provided with a resetting plunger, viz., the sending portion. We have thus two rods in connection with the block instrument —one rod I, the other rod S.

The block instruments consist of sending and receiving portions, combined in one case, but represented independently in the diagram in order to make the explanation more clear. The sending portion is a plunger, G, which on being pressed in forms contact between the spring, F, and the studs, D. A current is thus sent to line, which current is arranged to be of the opposite sign to that used for the bell; the object of this is, that should a foreign current encroach upon the line wire, it must be of the same sign as that employed in working the instrument in order to release the lock. The movement of G mechanically thrusts away a click piece which rests on the top of the rod, S, so that the bar, U, with the lower tablet or flag falls to "train on," thus affording the signalman a visible sign of the signal rendered by him for an incoming train. This done, the plunger becomes locked and cannot again be used, its motion being stopped by the projection, V, so long as the signal "train on" is being exhibited.

The incoming current from the block post in advance traverses the following course: Arrived at F, it passes into the stud, 6, and thence to the wire connected with the coils, E, of the permanent magnet, E^1, and thence to earth. The poles of the permanent magnet, E^1, are extended by soft iron cores, employed to form an electro-magnet. The armature, *f*, is attracted towards these cores by the influence of the permanent magnet, E^1, except when a current is passing through the coils of such a character as to reduce the force of the magnet. When this is the case, the armature, *f*, is drawn away from the cores by the influence of its own weight and a spring provided for that purpose. The armature is extended at right angles so as to form a crank, the upper end of which engages by a shoulder, or pin, with the rod, I. It will now be clear that on a current of the required direction being passed through E, *f* will no longer be held by E^1, but will fall away and fail to support the rod, I, which falling by its own gravity will influence J, and raise the locking pin, K, so as to set free the lever for the starting signal. We may now draw over the signal lever. In doing so, P engages with O, and again lifts the rod, I. I carries a projection, accommodating an adjusting sorew, *g*, and when I is lifted by P, this adjusting screw, *g*, engages with the armature, E, and again carries it into that position which again brings it under the influence of the permanent magnet, E^1, and it again becomes fixed in the locked position. On the rod, I, being raised, K falls and rests upon the bar, L, and on the signal lever being restored to the "on" position, K will drop into the notch provided for it and lock the lever.

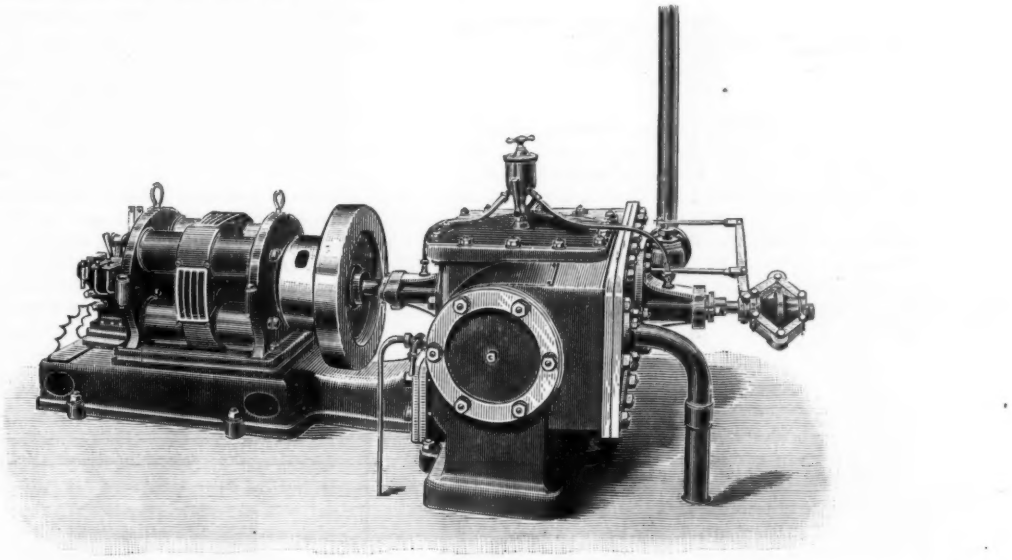
In order to obtain the reverse currents for working the indicator bell circuit, a spring, 4, is provided in the block instrument, which is connected to the front, or battery contact of the bell key. In its normal position it rests against the contact, 5, and so picks up the ordinary bell (zinc) current. Should the bell key be now used, a zinc current will pass to line on the bell wire lowering the semaphore indicator at the adjoining station to the clear position at the same time that it rings the bell. When, however, the mechanical lever is put over, it not only locks the plunger as before described, but moves spring 4, and presses it against the contact which is connected with the copper to line battery. Thus, on the bell key being again used, the bell at the distant station is again rung, and the semaphore arm now raised to the blocked position. The mode of working is as follows:—Station A. signals to Station B. the "be ready" signal on the bell. B. now uses his plunger, pressing F against D and thereby sending a copper current to line on A.'s block wire. This current enters A.'s instrument at F, and passes thence to contact 6, and on through the coils, E, of the permanent magnet, E_1. The armature, *f*, is thereby released and falls away freeing the rod, I, which in its turn releases K and sets A.'s starting signal free. A. pulls over his signal lever and the train passes on towards B. A. now protects the departing train by placing his starting signal lever at "on," and in doing so—the locking gear having been again restored by the previous action of his signal lever, as previously explained—his lever is again locked until released for a future train by station B. The departure of the train is signalled in the ordinary manner upon the bell and, in like manner, B. seeks permission to send the train on to C. On C. giving B. the "free" signal, B. is able, on the arrival of the train from A., to signal its receipt to A., and in doing so to lower the bell semaphore arm to the clear position; thus restoring the apparatus at A. working with B. to its normal condition.

BEVER'S PATENT HIGH SPEED ENGINE.

THIS is a single acting engine with two cylinders on opposite sides of the crankshaft and coupled to cranks opposite each other. The engines are made either high pressure or compound, and the cylinders are so proportioned that the pressures are equal on each side, thus perfectly balancing each other on the crankshaft. The high pressure piston is connected by a straight rod to the centre crank pin, and the low pressure one by a forked rod to the two side crank pins ; by duly proportioning the weights of these rods and pistons they can also be made to balance each other.

The distribution of steam is effected by one valve, which is mounted direct on an eccentric portion of the crankshaft, and being guided by a link at one end, has a sort of oscillating motion imparted to it ; this motion has the effect of always keeping the valve faces in good condition, and prevents any possibility of cutting the faces. The steam is admitted at the back of the valve at one end and exhausted at the other, in both cases a steam-tight joint being obtained by a packing ring pressed against the valve chest cover by springs.

The lubrication of all the working parts is perfectly automatic, and is effected by the parts dipping into a bath of oil and water at each revolution, the oil being always kept at one level by an arrangement which allows the water to run off through an overflow when it exceeds a certain fixed height.



The engraving shows an engine coupled to a Gülcher dynamo and designed to run at a speed of 700 revolutions per minute with 80 lbs. of steam. These engines work with very great economy of steam on account of the high rate of expansion obtainable. An engine like that shown in the engraving has been exhibited by Messrs. Bever and Dorling at the Saltaire Exhibition, driving a Gülcher dynamo for arc lighting.

ELECTROLYSIS OF SULPHITES.

By RANKIN KENNEDY.

TWO years ago a proposal was made to the author which led him to make some experiments on the electrolysis of the liquor obtained from blast furnace gases by a process of mixing the gases from the furnaces with sulphurous acid gas made from pyrites. The mixture took place in a tower through which water percolated, the result being the formation of a solution of ammonia sulphite by the combination of the sulphurous acid with the ammonia in the gases from the furnaces.

This solution is afterwards treated with lime and the ammonia distilled into sulphuric acid to form sulphate of ammonia—a marketable commodity.

The proposal was to convert the sulphites in solution directly into sulphates by electrolysis, and thus dispense with the lime, distilling, and sulphuric acid. A few preliminary experiments were made which proved that the solution as it came from the mixing towers was an excellent conductor electrolytically, and that carbon electrodes were suitable for the work.

Carbon blocks in porous pots were used as cathodes. These were placed in tubs and surrounded by carbon blocks used as anodes. A large current from a dynamo was then turned on—a voltmeter and ammeter in circuit. For a short time no effect was observable, and iodine tests showed no change in the sulphites. At the end of the first hour sulphur, in the form of a pure pale yellow cloud, began to form at the bottom of the anode vessel. Tests then proved that the sulphites were being converted, and at the end of an hour-and-a-half no trace of sulphite remained, the whole having been completely oxidised to sulphates. The curious result was the formation of pure sulphur, and from this I concluded that the conversion took place partly by the sulphites dropping sulphur, and partly by taking up oxygen at the anode.

At the cathode the liquid became strongly alkaline, and gave off hydrogen and ammonia gas, while the anode liquid gave off sulphurous acid gas and became strongly acid. The ammonia gas and sulphurous gas rising from the liquids met each other, and combining formed a smoke-like cloud over the liquids. That oxygen was taken up at the anodes was proved by the formation of water at the cathode where the liquor increased and became more dilute.

After the successful conversion of the sulphites into sulphates by electrolysis the liquor was filtered to secure the sulphur and then boiled down to crystalise the sulphates.

The experiments made with measurements on a larger scale proved that this mode of recovering ammonia in the form of sulphate was cheaper and better than the sulphuric acid and lime process, and it might be adopted profitably by gas works as well as by iron works.

Some other experiments of interest to practical electro-chemists will form another paper bearing specially on bleaching by electricity.

Erratum.—In the correspondence columns of our last issue the date of Messrs. W. H. Smith & Son's letter to us should read "October 12th."

TRAIN TELEGRAPHY.

AT the invitation of the Consolidated Railway Telegraph Company, of New York, a large party of electricians and others made a trip upon the Lehigh Valley Railroad, on Thursday, October 6th, to inspect the operation of the system of train telegraphy in use upon 54 miles of the road.

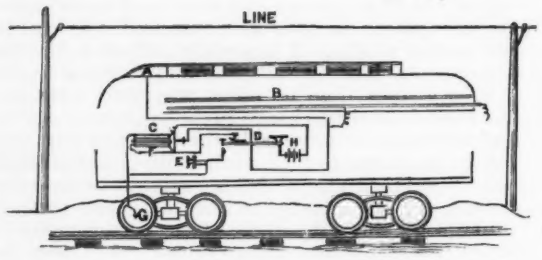


FIG. 1.

CAR EQUIPMENT FOR RAILWAY TELEGRAPHING BY INDUCTION.

A—Roof contact.
B—Rod or strip of metal, substitute for roof if roof not practicable.
C—Secondary of induction coil.
D—Double pointed key with extra contact.
E—Telephone receiver.
F—Primary circuit.
G—Ground contact on box.
H—Battery.

The system, due to Edison, Phelps, Gilliland, Smith and others, is well known in its main feature to our readers, but certain modifications have been introduced which have greatly improved its efficiency, so that as it now stands, all the difficulties heretofore encountered may be said to be entirely overcome.

In the first equipment on the Lehigh Valley Railroad the inductive receiver on the car consisted of a coil of many turns of wire wound around the car, and the line conductor was an insulated wire laid along the track. While this system left little to be desired, it involved some expense which is avoided by the method used at present. This consists in the employment of the roof of the car, where such is available, as a static receiver, and the line is an ordinary wire strung upon short poles near the track.

With the present system the roof of the car is, in most cases, available, and a car can be equipped ready for work in a remarkably short time. All that is necessary is the attachment of a wire to the roof, another to the swivel plate of a car truck for a ground, and the insertion of the instruments in the circuit thus formed. Such was the arrangement of the directors' car which was attached to the special train on the excursion, and the whole equipment did not occupy ten minutes.

The system as it exists to-day, briefly stated, consists mainly in the use of the "short pole" telegraph line extending along the side of the railroad track at about a distance of 8 or 10 feet from the line, the poles being much smaller than ordinary telegraph poles, and from 10 to 16 feet high. At their top is placed an ordinary glass or porcelain insulator, strung upon which is a single galvanised steel (or iron) telegraph wire about No. 12 American gauge. As remarked before, wherever practicable, the metal roof of the car is employed as the inductive receiver of the car, but where no metal roof exists an iron or brass rod or tube half an inch in diameter is employed, placed under the eaves of the car. From the roof, the wire passes to the instruments, and then to the wheels of the car. The diagram, fig. 1, shows the arrangement. The roof, A, or bar, B, are connected to the secondary, C, of an induction coil. The primary of the coil is connected to the front contacts of the double-pointed key, D, in which is also included the battery, H, and a buzzer arrangement opposite the core of the coil, for transmitting a series of impulses to the line whenever the key is closed. When the key is upon the front contact also, the extra contact shown at the top of the key closes the secondary circuit and allows the charges to be sent into the roof. When the key is on its back contact, both the secondary and the primary coil are cut out, the charge from the roof passing by the wire from the roof directly to the key and thence through the telephone to earth.

The operator's equipment is quite simple, and consists merely of a small tablet to which the key, the coil and the buzzer are attached, and with just sufficient top surface to hold a telegraph blank conveniently, as shown in fig. 2. The battery employed is inclosed in a box and can be placed beside the operator, as shown in fig. 3, or can be stowed away in one of the closets of the car. Our illustration shows the operator exactly as he appears on the train with the telephone supported by head gear. A battery of 12 small cells is employed in circuit with the primary of the induction coil, although it is stated that communication can be kept up with two cells. The primary and secondary of the induction coil are respectively about 3·5 and 250 ohms. The receiving telephone is wound to 1,000 ohms resistance, and Mr. Phelps assures us (*Electrical World*) that even when wound to 10,000 ohms the sound produced is quite as clear as with the 1,000, of such high E.M.F. is the induction upon the roof.

The arrangement at the terminal station, so far as the induction circuits and instruments are concerned,

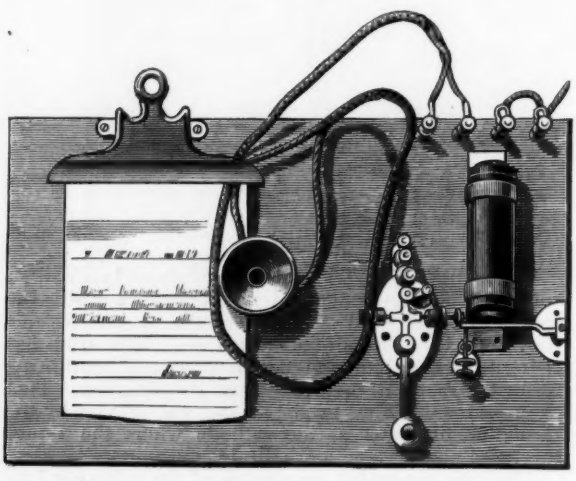


FIG. 2.—SENDING AND RECEIVING INSTRUMENTS USED ON TRAIN BY OPERATOR OF CONSOLIDATED RAILWAY TELEGRAPH COMPANY.

FIG. 3.—OPERATOR'S OUTFIT, BATTERY, INSTRUMENTS, &C.

is identical with that on the car; but in addition there is supplied a Morse arrangement, as shown in fig. 4, by means of which the line can be used for the transmission of ordinary Morse business. The circuit is made continuous for the induction system by means of the condenser, K, which transmits the impulses when the Morse key, I, is open.

The cost of equipping a railroad with this system depends somewhat on the character of the roadway, nearness to telegraph pole markets, &c.; but it is said to approximate about $50 per mile for line equipment, *i.e.*, poles, wire, &c., and the labour of putting up. The cost of car fitting is about $15.

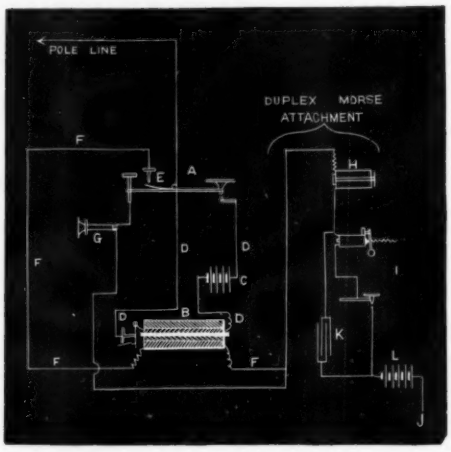


FIG. 4.—ARRANGEMENT OF APPARATUS AT TERMINAL STATION.

A—Double pointed key.
B—Induction coil.
C—Battery.
D—Primary circuit.
E—Extra contact key.
F—Secondary circuit.
G—Telephone circuit.
H—Electro-magnets.
I—Morse apparatus.
J—Earth connection.
K—Condenser.

On the occasion of the recent trip, a large number of messages were sent and received from the train without the slightest delay of any kind, the arrangements being under the charge of Mr. S. K. Dingle, assistant superintendent of the company.

One of the most striking demonstrations of the wide application of the system was the sending of the following dispatch by Colonel Gouraud, from the rapidly moving train to Mr. John Pender, of London, England, *viâ* the Atlantic cable :—

"John Pender, Direct Cable Company, London, England.

"As a representative of so great a portion of the world's telegraph system, you will be interested to receive, as it is my privilege and pleasure to send you, this greeting under the following extraordinary and interesting circumstances. I am telegraphing these words while comfortably sitting in a palace car of the Lehigh Valley Railroad Company, flying through the beautiful valley of that name at a rate of something more than 60 miles an hour, by that marvellous system invented by Edison and Phelps, known as the induction telegraph, there being of course no wire connecting the train with continuous telegraph wires over which the message is now passing, the current jumping from the car to the wires a distance of 25 feet. We are telegraphing in the same manner to any or all trains on the railway, each train being equally in connection with the train dispatcher. This is the first message sent in this manner for transmission from America to England. A large party of representative telegraphists and scientists are the interested and applauding guests of the Consolidated Railway Telegraph Company, amongst which are many of your American friends, including Mr. Edison and President Cheever, who send their kindest regards. "GOURAUD."

The Manchester Exhibition.—This exhibition finally closes on the 10th ult. The attendance has been wonderful. On Saturday last 66,000 persons were admitted and on the previous Saturday 74,000.

A SHORT HISTORY OF ONE OF PROF. MOSES G. FARMER'S DYNAMO-ELECTRIC MACHINES.

MR. CHARLES STOWELL has written the following interesting communication for the *Electrical Review* of New York :—The machine was built in the latter part of the year 1873, and experimented with at 15, Congress Street, Boston. About 175 lbs. of No. 16 copper wire were used on the field coils and armature, the whole machine weighing 900 lbs. There was no steam-power in the building, and so a large cast iron wheel, with belt to machine, turned by two men, was used. The arc light was with carbons, adjusted by hand.

It being a great curiosity many came in to see it, and among them Mr. Frost, chief engineer of the Hoosac Tunnel. He was so well pleased that he wanted to have the whole thing sent up there to try the light at the heading. Mr. Frost said he had men enough to turn it. Mr. Farmer sent his assistant up to the tunnel to see if there was any way to utilise the compressed air that they were using in driving the Burleigh drills. He went and reported favourably. An electric lamp was made and the machine and lamp were taken to Mr. Thomas Leavitt's machine shop, where it was run successfully by steam. It was never taken to the tunnel for this strange reason, that there were not enough carbons in Boston to supply this one lamp a single month. All carbons were imported then.

The machine and lamp was exhibited at the Mechanics' Fair, in Quincy Hall, in the fall of 1874, together with two torpedo machines, and a silver medal was awarded Mr. Farmer. A reflector was used with the lamp, and the light was so intense that shadows of the gas flames were cast, the gas jets being more than 150 feet from the electric light.

This is believed to be the first electric arc lamp exhibited in this country where the electricity used was generated by a dynamo machine. In the year 1851, at New York at the Crystal Palace, an electric light was exhibited, but the current was from a magneto machine.

As soon as the fair closed, the machine was taken to the Inst. Technology, and a series of experiments made with it by the professors.

It remained there until June, 1875, when Mr. Charles Stowell took it to Philadelphia to the Centennial grounds, near to the then unfinished Art Gallery. This was done at the suggestion of Prof. Geo. F. Barker, who had charge of the experiments, and who also had his own Gramme machine mounted upon a waggon (with portable engine to drive it), drawn to George's Hill. The Farmer machine furnished a light on the dome of the Art Gallery. Both lights were used on the evening of the 5th of July, 1875 (the 4th fell on the Sabbath).

The committee of the Centennial Exhibition were present, and desired to try still farther, so the lights were lit again on the 6th. This time the Farmer machine lit the lamp on the top of a hastily constructed wooden tower, near the main entrance to the grounds, and Prof. Barker's was used all over the grounds, being drawn from place to place, as the committee desired.

The Farmer machine is still in existence, but has not been used. A few years ago it was proposed to place it among other electrical devices in Franklin Institute.

I would much like to know if any of the readers of the *Review* know of any earlier dynamo machine. Mr. Farmer told me he was pretty sure it was the first.

An Electrician's Pocket Tool. — A combination pocket tool for the use of electricians has been designed by Mr. William J. Hammer, of Boston. The tool includes a screwdriver, a wire cleaner or pencil sharpener, a Birmingham wire gauge (ranging from No. 3 to No. 20), a comparative scale of English inches and French millimetres, and a combination wrench.

ON ELECTRIC STREET CARS; WITH SPECIAL REFERENCE TO METHODS OF GEARING.*

By A. RECKENZAUN, C.E.

DISCUSSION.

The PRESIDENT: Gentlemen, the valuable paper to which you have listened is now open for discussion. It is natural under the circumstances that as we have Mr. Reckenzaun with us but once, and as he is about leaving for Europe, that we should, so to speak, put him in the witness box, and puzzle, perplex, and annoy him with questions. In that way I have no doubt we would greatly add to our stock of information on the subject. But I know Mr. Reckenzaun would, if anything, prefer a discussion rather than a series of interrogations, and I think that on the matter presented before us to-night, and with half the gentlemen in attendance directly interested in street railways as run by electricity, the subject should not lack ventilation, and I venture to believe that should any gentleman desire to discuss some of these points with Mr. Reckenzaun he will find a foeman worthy of his steel.

The SECRETARY: There is one point in connection with the worm gearing which I have heard referred to before, and I presume, as Mr. Reckenzaun's name was mentioned in connection with it, he can give us further details, and that is the matter of lubrication. I understood when this question was up before, that in his use of worm gearing the worm was run in oil, and if so, I would be pleased to hear some further details.

Mr. RECKENZAUN: (making a sketch showing the worm and the worm wheel enclosed in a case): The thrust bearings are generally made of several collars. There is a tin box completely around the gearing, having a hole for the shaft, with a very tight stuffing box. The whole gearing is thus closed almost air tight. If you place ordinary lubricators above, just to start the thing, and if you place two or three inches of oil at the bottom of this tank you will find that there is a perfect, continuous, automatic lubrication. The teeth of the worm wheel will lift up just sufficient oil to lubricate the worm, and there will be sufficient oil always running around—flying about inside the case—to keep the whole thing well lubricated. There is hardly any waste of oil going on, through leakage at the shaft, or here at these points. Thus you have a perfect lubrication that cannot fail at all. I believe this is the only question that Mr. Pope asked with reference to the lubrication. Of course you can use any lubricant you wish. Some lubricants are far more efficient than others. Naturally, we should use the most efficient lubricant we can get in the market. With regard to the friction surface of the worm wheel, I have mentioned that that is made of phosphor bronze and the worm is made of steel. These two metals have a very low coefficient of friction between them. The worm is, moreover, turned out of a solid piece of steel and perfectly polished. The phosphor bronze wheel is a toothed gear, the teeth thoroughly trimmed, and also polished inside. They have, therefore, a perfect wearing surface to start with. The worm gearing works for a considerable length of time without any appreciable wear on the teeth at all. I think a perfectly constructed worm gear ought to run 20 years without renewal if properly lubricated. The prejudices against the worm gearing will soon wear away. Up to the present time it has been constructed on anything but scientific principles. The teeth were at a very small angle. The material used for the worm was frequently cast-iron. The worm wheel was sometimes made also of cast iron. Sometimes they made wrought-iron worms and cast-iron wheels.

Mr. WETZLER: I would like to ask Mr. Reckenzaun if he has ever tried to use a worm which, instead of being cut cylindrically, has been cut so as to conform to the radius of the wheel into which it geared.

Mr. MAILLOUX: The hour-glass form.

Mr. WETZLER: Yes, the hour-glass form, as Mr. Mailloux says.

Mr. RECKENZAUN: All the worm gearing I have constructed has been made on the plan of cutting it out cylindrically.

Mr. WETZLER: The worm having the hour-glass shape is said to be more efficient, according to Prof. Thurston's experience.

Mr. MAILLOUX: I would like to add by way of information, that this form of worm was the very first that was used. If I mistake not, it was the celebrated mechanician or engineer Hindley, who first devised the worm, and it was in that form that he gave it to the world—the hour-glass form as he called it. The shape of the teeth is varied as they go toward the end near which they point inwardly in a radial form, as Mr. Wetzler has said. With regard to the worm, I have watched with interest the evolution, so to speak, of means of transmission from the motor axle to the car axle, and I am very well prepared to agree with our friend Mr. Reckenzaun, that it is undoubtedly one of the most important problems that we have to deal with to-day. In fact, I may say that it is the only remaining unknown quantity in the problem of electrical traction. The problem of designing and constructing electric motors has advanced by the assistance of workers, mathematicians, and others, until it is to-day a question of engineering, you might say, almost purely; but the manner in which we should dispose of the energy in order to render it available for moving the car, is not, unfortunately, so well taken care of; and the very fact that we see so many diversified attempts to meet the severe requirements which Mr. Reckenzaun has so well placed before us, shows that a satisfactory solution—at least one that is satisfactory to everybody—has not yet been reached. Some are very much predisposed in favour of belting, others in favour of gearing, friction appliances, &c. Now there is going to be, I believe, a certain amount of competition between different forms of gearing, leaving aside for the present other methods, such as belting, &c. There is to be some divergence of opinion for some time to come, as to which is the best form of gearing. Experiments have been made by very able persons on the subject, and, so far, nearly all of them concur in ascribing to the worm a much lower efficiency than to the spur form of gearing. I have in mind some experiments which were made under the auspices of Messrs. Sellers, of Philadelphia, in which they sought to go thoroughly to the bottom of the problem, and to arrive at some conclusion as to the relative efficiencies of the various forms of gearing. The results attained show first that the efficiency did increase with the speed, as Mr. Reckenzaun has stated, but that this efficiency did not increase always with the speed; that it reached a certain maximum just as you would expect; and a very curious circumstance was that the forms giving the highest efficiencies were those two ordinary direct spur gearings in which the shafts are parallel with each other. Starting from that they made experiments in which the angle of the two shafts was gradually increased so that there was, so to speak, a gradual transition from the form in which the two shafts were parallel to that in which the two shafts were at right angles to each other, as in the worm gear. We may say, in fact, that worm gearing and spur gearing will be the two extremes of a certain scale of transition, the so-called helical gearing in which the teeth are placed at an angle in spirals, being placed intermediate between the two extremes. The results obtained by the Messrs. Sellers, or the persons who carried on the experiments for them, showed that the nearer they approached the form of the worm, the lower was the efficiency. I have not in mind the figures of the efficiencies, but the experimenters themselves rather left us in doubt as to the value of their results, by referring to very many circumstances which, in their opinion, would vitiate some of the results obtained, and there were certain conditions of the operation of their apparatus, &c., which they were not exactly satisfied with. I must say for myself that I have always looked upon the worm with more or less suspicion. While I was not prejudiced against it, particularly after seeing the beautiful results obtained with it by Mr. Reckenzaun, in England, yet at the same time I felt that it was to be taken under probation, so to speak. There are some disadvantages, I think, which are connected with the use of the worm, and one of them which occurs to my mind just now is the difficulty in running down hill when the worm is fastened to the motor shaft. When an electrically propelled car runs down a grade it is usually found possible to shut off the current in a great many instances, and this, of course, results in a certain saving of energy. Now, unless the pitch of the thread was properly calculated, it seems to me that it would be somewhat difficult for a car to move down hill with ease, because of the well-known difficulty of moving such an arrangement backward. It is very well known that a thread can be used to turn a toothed wheel, but it is very hard to turn the thread by means of a toothed wheel. I understand that Mr. Reckenzaun has met this difficulty, though I do not know whether he still considers it one of the things to be remedied, or whether he deems the remedy that he has proposed sufficient. Now, turning back to the other form of transition, namely, the pinion, which I have said is likely to be one of the opponents or rivals of the worm system, I have in mind some form of that kind which I saw in use a year or so ago, which it seemed to me was very well adapted for the purpose that it had to serve. Recognising the fact, of course, of a great tendency to wear, in the pinion or in the gear wheel, and also the great tendency to the production of noise, a special form of pinion had been devised. This was made by taking a number of thicknesses of raw hide or leather—I think it was raw hide—and closely packing them and threading them, so to speak, on the shaft, with nuts to hold them in place, then cutting inside a thread so as to make a pinion of these thicknesses of raw hide. The gear wheel, I understand, was of phosphor bronze—it had that appearance. I made some experiments with that system at Providence, at the works of the Rhode Island Locomotive Works. I think the name of the system was the Bentley-Knight. I found the working of it to be very satisfactory. It was entirely noiseless, and the only doubt that there was in my mind as to its success was the question of durability of the pinion. I have no doubt that if there is any wear it must necessarily come on the pinion, that being the softer substance of the two; but I have no data by which I could arrive at the comparative durability of the raw hide pinion. With regard to the chain, I may add a word which might be interesting by way of information. My experience with it goes to show that the loss from its use is not nearly so great as might at first be supposed. In that respect the pinion is placed in very nearly the same position that the worm gearing is. In other words, it depends largely on who is using it, and how it is used. Mr. Reckenzaun has obtained excellent results—nobody will deny that—from that worm gearing which has always been looked upon as the bane of the mechanic. Now, the same may be stated with regard to the chain belt. It is capable of giving excellent results, but in order to obtain them a special form of chain must be used, and the secret of the success which Mr. Van Depoele has achieved in this country is due largely to the special form of chain which he has used. The connecting piece between the links has a

* Read before a special meeting of the American Institute of Electrical Engineers, September 20th, 1887.

thimble around it which acts as a roller, so that instead of having a frictional action on a toothed wheel it has more of a rolling action, and by taking care to keep the chain properly lubricated, not only is the noise greatly reduced, but the loss from friction is also very largely diminished.

Mr. RECKENZAUN: I think there is only one point which requires observation on my part, and that is in regard to running down hill with worm gearing. I make the angle of this thread so that the car runs down hill very easily if we once start the worm. You can with your hands turn the worm wheel around almost at any speed you like, and I know from experience that a car which is provided with worm gearing will run down an incline of one in seventy to one in a hundred—it depends on the roughness of the track—very easily. If it were not for that, if the pitch or the angle of the worm thread were not sufficiently great there would be more danger, even in the case of running on the level road, than running down hill, because as soon as you cut off the current from the motor the momentum of the car would strip off all the teeth of the wheel. If you make that angle sufficiently large you will find there is no trouble at all with reference to that point which Mr. Mailloux has pointed out. If you take the formula which I have given on the black-board, and which I suppose will be published some day, and if you take the dimensions I have put down, you can get the exact angle of the worm thread, and you will find that its angle of repose is so low that the worm wheel is bound to revolve with the greatest of ease. As regards spur gearing, I have pointed out in the course of my observations in the paper, that I have been very well satisfied, in fact, astonished with the ease with which that spur gear which we use in Philadelphia is working. As regards chain gearing, I have been rather unfortunate with chains, but if I had employed such appliances as Mr. Mailloux or Mr. Van Depoele, no doubt I might have been more successful. Of course Mr. Van Depoele uses rollers, and we know that rolling friction is much easier than what I call grinding friction, where the links of the chain have to grind over the teeth. I agree with Mr. Mailloux that there will be a great competition between the different forms of gearing, and it is only that form of gearing which lasts longest and gives the least trouble which will be eventually adopted generally. But at the present time we are still in the dark as to the best form. Everyone believes his own the best because he has had the greatest experience with his own form. Any discussion of the description we have had to-night will greatly advance the subject.

Mr. WHEELER: I want to ask Mr. Reckenzaun how the gear was connected to the motor. If the motor was mounted directly on the worm shaft, did not the jarring of the car shake the motor up a good deal, and prevent the brushes resting on the commutator? I do not think he has explained that.

Mr. RECKENZAUN: No, sir, I have not explained that. The worm and its coupling are generally forged in one piece. I employ a slightly flexible coupling between the motor shaft and the worm shaft, and between the bearings are springs, which take off the jarring from the bed of the motor. There is very little jarring going on—comparatively little—and we have never had any trouble with the jumping off of the brushes from the commutator. If the springs on the commutator brushes are sufficiently strong there will be no trouble. In some cases I have tried—taking the brushes of the commutator to be almost horizontal—I have tried putting a balance on, so that the jarring, instead of jarring it off, jars it on, and puts pressure upon it. I found at last there is no necessity for that. There is very little trouble in that respect if it is properly adjusted in the first place. With this flexible coupling in the first place, and the wheel flexible to the bearings that support the frame of the commutator, you will find very little trouble on the points Mr. Wheeler has mentioned.

Mr. WHEELER: If that motor jars up and down at all it either must twist on the foundation or else there would be a fault in the shaft.

Mr. RECKENZAUN: Yes, there will be a slight fault in the shaft; but if there is a flexible coupling between, it will compensate for that. Of course we do not expect it will be half an inch out at any time, but it will allow a variation of an eighth of an inch.

Mr. WHEELER: That ought to do it.

Mr. MAILLOUX: I would like to call attention to a point which I put down as the first on my list, but which, in my anxiety to get through, I omitted. I do not wish to see it passed by, because I think it is of some importance, and perhaps throws light on these discrepancies relative to the efficiency of the worm which have been observed in the results of the best experimenters. I have reference to end-thrust in the motor. My own study of the theory and practice of the worm wheel has convinced me that at least a large proportion of the waste of energy due to friction in worm gearing must have been due to end-thrust. Now the question arises, did not Mr. Reckenzaun, perhaps, employ means by which this end-thrust could be reduced, if not eliminated, and in that way obtain a much better efficiency than the others who had preceded him? I wanted to mention particularly that in analysing the experiments made by Messrs. Sellers, I was not satisfied with the precautions that they seemed to have taken to eliminate that end-thrust, and perhaps that may have been the cause of considerable loss of energy by friction. Now there is another point which occurs to me, and which I will beg the privilege to discuss while I am up. The problem of electrical traction involves a very important requirement in the matter of securing adhesion between the rails and the wheels in climbing up grades, going around curves, &c. The electric motor has not been found successful in enabling us to climb grades higher than six per cent., or at the outside seven per cent. I have succeeded in going up a grade of six per cent. with a motor car having another car attached to it. But these are *tours de force*, so to speak, which perhaps we would not care to repeat every day. Then if we admit the necessity for a certain amount of traction—adhesion between the motor and the rails—we arrive at the consideration of the importance of having the power transmitted to both axles. In a great many cases I have found by experience that the transmission of the motion to one axle was insufficient in certain kinds of weather, when the tracks were not in the right condition. There would be a very severe and annoying amount of slipping, which would greatly interfere with the progress of the car and the success of the experiment. Now another requirement which has presented itself in my study of the problem is this—the difficulty of starting easily, smoothly, and without hesitation, so to speak. That is a more important item of the problem than people generally imagine, and I have in mind several systems of electrical traction which are successful in almost every respect but that. They start with a certain jump which is likely to strain, if not to rupture, some part of the mechanism of transmission, and in connection with this it has suggested itself to my mind as being an eminently desirable end to attain, to have means by which the motor could be started independently of the car. As you know, there is a certain amount of energy to overcome in the motor itself, and a certain amount of energy must be expended in giving it the velocity at which it is to be run. Now if we could do that first and not have to do it at once, or simultaneously with the overcoming of the inertia of the car itself, you will see that we will have made some gain. It would be very much like dividing a load into two portions, instead of having to lift it all at once—lifting a small part of it and then going on to lift the rest. That suggests itself to me as a very important question, and I believe that the successful system will be one in which that feature is present. I would like to hear the opinion of Mr. Reckenzaun.

Mr. RECKENZAUN: With regard to eliminating the end-thrust of the motor in the case of worm gearing, I use no special precautions whatever, excepting that I employ several thrust collars. I believe Mr. John Pendleton has a system of worm gearing in which the thrust is eliminated by having two worms, one right-handed and the other a left-handed worm, so that the thrust of the one counteracts the thrust of the other. But it has this little disadvantage, that the gearing comes very near to the ground. There are two worm wheels and the motor shaft is at a tangent to the two wheels. The motor is between the two worms. By this means the two driving wheels have to revolve in the same direction. The two worms revolve in the same direction, and being right and left-handed, the thrust is entirely eliminated. I have made one kind of worm gearing, for a special purpose, where two worms were attached to a motor which drove two worm wheels, and on the same shaft with the worm wheels were two large spur wheels, which were used for climbing up a rack. In this case, also, the thrust was eliminated, so that there was only the friction of the thread of the worm, and the worm wheel teeth. With regard to the problem of adhesion, it is perfectly natural that the more driving wheels you have, the better will be your adhesion, because each wheel will have the same effect in assisting to start the car. I never use less than four driving wheels on my cars. I would use six if it was convenient.

Mr. MAILLOUX: How do you connect them?

Mr. RECKENZAUN: I use two small trucks with pivots, on which the car body is supported. The car has two motors. There are four driving wheels and two driving axles. By extending the shaft we could have a second worm wheel; but that would complicate matters very much unless it was absolutely necessary for very steep grades. It is nonsense to attempt to run cars on a grade of more than 6 per cent. in wet weather. It is impossible. No electric car or steam car, or any self-propelled vehicle will climb grades of more than six per cent. in slippery weather with absolute certainty. If we go beyond 6 per cent., we must have some artificial adhesion; we must introduce some rack on the road, or cables, which have a positive motion. Any one who attempts to guarantee a self-propelled vehicle, whether propelled by steam or any other means on grades of more than 7 per cent., will most certainly lose his reputation. With reference to starting, I have always found that electric cars start with remarkable facility; that is to say, with remarkable quietness. There is very little jerk. Mr. Mailloux mentions that most electric cars start with a jerk. I know that steam cars, cable cars and horse cars start with a jerk, but I have very seldom found it on electric cars, and I have had the privilege of riding on a good many electric cars in various parts of the world. There is a gentleman here, Mr. Stein, who I think might give an opinion on that subject. He has been on our car in Philadelphia, and I think he would assure you that it starts easily. You can hardly feel the starting; it starts gradually, and that is perfectly natural. When the current is transmitted to the motor the motor has no counter-electromotive force. Therefore the whole of the current that goes through is due to the actual wire resistance of the motor. As soon as the motor is started, as soon as the armature revolves, the current decreases immediately in proportion to the relative speed of the armature. As the counter-electromotive force is created in the armature by its revolution, so the current is reduced, and it is almost impossible to start an electric car suddenly with a great jerk. I think those are the main points Mr. Mailloux touched upon.

Mr. J. M. PENDLETON: In regard to the electrical propulsion of

cars, while the first efforts were being made in Paris by Mr. Phillippart, in the celebrated omnibus feat, with which he paralysed the residents of Paris by the exhibitions made on the Boulevard and also the run from Paris to Versailles and return, my attention was drawn to the question of power contained in the accumulator for the purpose of car propulsion, and while an examination of that apparatus failed to satisfy me as to its being a mechanical arrangement affording the best efficiency, yet the results attained in that demonstration convinced me that the value of the accumulator and motor will find a better application in the replacing of horses than of anything else, and as I was devoting my attention to experiments with the accumulator during those years, I gave a good deal of study to improving the mechanical devices then adopted, which were simply the connection of a D 2 Siemens dynamo with the counter-shaft, and from the counter-shaft to the wheels of the omnibus, which was borrowed for the purpose, and my recollection is that the apparatus weighed about nine tons. We are all familiar with the demonstration made, and a good many are familiar with the devices used, but when I made the attempt to find something better it appeared that, according to the experience of carmen, and in the opinion of those who had employed various devices with compressed air or steam, it was a very difficult subject. Our oldest car builders in conversation told me that the experiments had so far demonstrated that horses were the best things to put on cars and nothing else would do; that engines would not stand the pounding of the rail. They were very rapidly destroyed. Occasionally some invention would run smoothly for awhile, but that inevitably it came to grief in a very short period. Notwithstanding this discouragment, various devices such as have been spoken of to-night were reviewed one after the other, and the device which Mr. Reckenzaun has alluded to was the final result, after discarding some dozen or more, and in his sketch to-night the principle was correctly shown. But the necessity of using the worm and worm wheel running in oil was very evident to my mind. It may be remembered by a good many here that in May, 1886, I exhibited at the New York Electrical Society a design for this system of car traction, having eliminated from it all the objectionable features that could be well done on paper. I exhibited it for the purpose of getting the opinion of those who were engaged with me in investigating mechanical and electrical questions. I was discouraged afterwards by the opinions of many—some of whom are here present—as to the efficiency of the worm and the worm wheel, and it is with the greatest pleasure that I hear so well defined and so thoroughly proved by practical experiments what I may say was a chance choice, more than a scientific attainment on my part. It came to me intuitively, as it were; it seemed to satisfy me better than any other. I have had the apparatus in model for a good many months past, but other engagements have prevented my doing as much work in that line as I wished. The interest has increased from week to week. It is only a fortnight ago that I visited Philadelphia and had the opportunity of riding upon a car which Mr. Reckenzaun had in charge at the corner of Washington Avenue and Twenty Fourth Street. I saw there a car under thorough control, mounting grades of five feet in one hundred feet easily, stopping in the centre of the grade and starting without any difficulty. The starting from a dead stop was with ease—much more readily than we would experience in a horse car; and although I had been so many years a believer and exponent of electric traction, and particularly of accumulator traction for street cars, I will state to you that I was surprised and gratified at the practical demonstration of its value that I saw. The car was run by a motor attached to only one pair of wheels. It had always been a great doubt with me whether on grades of five to the hundred, or four to the hundred, that a car would have sufficient bite upon the rail to enable it to mount. I saw the car stop on a grade, start on a grade without any slip, and go over it, and I felt that a very important question was solved by the manner in which it performed its work. Gentlemen, there is no more doubt in my mind to-day in regard to electrical propulsion by accumulators replacing horses than that I am standing here. After the demonstrations that have been made, it is only a matter of a few months when we shall find one or two lines of horse cars adopting electrical propulsion, and then you may expect it to come like the roll of the sea. There will be no supplying the demand that will arise for electrical cars. I had the pleasure that day I was in Philadelphia of being associated with two presidents of horse railways who were witnessing these experiments, and they both expressed their surprise and delight at the manner the car behaved, and at the thorough control which it was under. We have only but a brief period to wait before we will find the advantages which the adoption of a new and better system will give to the general public, and to the welfare of our cities.

The PRESIDENT: There is one branch of the subject which has not been touched upon this evening, yet it merits our attention. We have so far confined the discussion to street cars, whereas this whole discussion might refer more largely to electrical cars in general. It may not be within your knowledge generally that within the last month or two an electrical road—the largest of the kind in this country—has been put in operation in the coal mines of Pennsylvania. We have with us this evening Mr. Schlesinger, who has put that road in operation and who has it in successful operation to-day. He there handles trains of a hundred tons weight, and his experience in dealing with the particular question that was touched upon, of moving off easily and quickly, without any jarring of the machinery, would be very valuable in this connection. I think it would afford us all a good deal of pleasure to hear of his experience in the Lykens Valley coal mines.

Mr. SCHLESINGER: In the Lykens Valley coal mines we enter into competition with one or two lines of horses and also with the steam engine. The mules were taken off entirely the second day, and I think that the steam engine has also seen its last days in the coal mines. It is proposed wherever steam locomotives are being used to change them for electric motors in a very short period. The trains we have to handle are sometimes as large as 100 tons. We have to take them over grades of about one per cent. to two per cent. and around 90 degree curves, one of them being 25 feet radius. We are obliged to start trains on these curves. The mode of transmitting the power from the motor to the wheel is chain gearing. I found that wherever the train stands, the starting is very easy, or would be very easy if it were not for the fact that the cars are generally bumped together, and the load is not all put at once on the motor, but gradually. One car starts after the other, and this is an objectionable feature so far as the easy starting is concerned. If the whole train started as one, then it would move off very nicely and easily, without any jar at all, and that is another reason why I think it is always preferable to have the motor geared in such a manner to the car, that both start together, not the motor first, and then the car; there will always be a jar if this is not the case. It is the same thing as if the chain gearing should have stretched. It will always be noticeable that the car starts far more heavily, and with a greater jerk, than if the chains are perfectly tight. Outside of that the weight and power required to stop the motor are so small, as compared with the power required to start the whole thing, that there is very little gained in starting one, especially the motor, before the other. The chains we are using in the Lykens Valley coal mines are the same Mr. Van Depoele is using, and side by side with that we use a chain which I have specially constructed for the purpose. The links are made of phosphor bronze and the pins are of steel. The chain with a thimble is not giving much satisfaction up there. I suppose it is because of the very heavy strain upon it.

Captain O. E. MICHAELIS: A remark that Mr. Schlesinger has just made in regard to the increased shock due to the successive movement of the cars constituting the train bring to my mind a remark that the reader of the evening also made in his paper, which I saw was clearly founded on experiments, and not simply the result of theory. That remark was that the duty upon the motor was greater in starting the train than afterwards, and Mr. Mailloux continued somewhat in the same manner. Now, during the present year there was a series of remarkable experiments made at Burlington under the auspices of the Master Car Builders' Association, which will bring about, I think, an entire revolution in the method of connecting trains, and I am fain to confess that these experiments appear to upset all our preconceived theories as to the duty of the motor in starting trains. I speak on the subject because I am at present engaged on this coupler question, and therefore take some interest in it. These experiments showed that the greatest duty upon the locomotive in this case was actually after the whole train had been started, and it is very curious. I am willing to admit that I was entirely mistaken myself, because at the very time, almost, of my receiving the account of these experiments, I had taken great pains to explain to a friend of mine the theory by which a train was moved by the successive picking up of the cars—a theory which was of course upset by these experiments. The result of that has been that the Coupler Committee of the Master Car Builders' Association—all prominent railroad men in active practice—unanimously agreed at the convention in Minneapolis that the future coupling of cars shall be tight and not loose, and have recommended the abolition of the pin and link coupler and the substitution of a close vertical hook, which I think coincides with what Mr. Schlesinger has said.

Mr. MAILLOUX: I stated that one of the difficulties was the sudden starting of electric cars. Now I should have said that circumstances were responsible for that. It depends very much on the way in which the energy is given to the car; and when you are dealing with accumulators it is not often possible to apply the electrical current to the car in a manner sufficiently gradual and slow to prevent that sudden onslaught of motion, so to speak. That is what I had in mind in speaking of the sudden motion. If the current is supplied over circuits with devices by which it can be put on more slowly or more rapidly, according to circumstances, the case is different; but with storage batteries generally, it is far more convenient to have as few combinations, as little mechanism, as possible in the regulating apparatus, so as to not complicate things. Now, with regard to the starting of the motor shaft first, the opinion I expressed was the result of experiments. I have seen the virtue and the value of that point demonstrated quite recently by means of a system in which the motor is started first, giving free scope to the full electromotive force of the battery and allowing it to run at a very high speed, and accumulate energy in the form of momentum, so that not only that part of the work has been done, but we have even stored a certain amount of energy there, which, when a device is applied, shall enable us to make use of that storage energy to start the car itself. I have seen the results demonstrated by a gentleman who has a system of traction, and I must say that it struck me very favourably indeed. He used a frictional device in the connection between the motor and the other, also combined with spur gearing; but when I saw the ease with which he started and stopped, and overcame grades, &c., I was convinced that there must be something in it. I still believe it

Mr. PENDLETON: I called Mr. Mailloux's attention to the value of the electric motor, particularly for the purposes for which we are applying it, and that is that the electric engine has its greatest traction at the time of starting, and was therefore more particularly valuable for the purposes of car traction than any other engine we know of, and in order to get this momentum of a small armature for the purpose of moving a heavy car, it would only invariably bring about the result of a jerk, which we have none of us noticed, so far, in the actual tests and experiments made. I have failed to see it. I have noticed particularly in regard to the cable cars that it is very disagreeable, for obvious reasons, but where we are using a 10 horse-power motor weighing 700 or 800 lbs., for the purpose, and the armature of which is but a fraction of the weight, the momentum there can amount to very little in a car weighing 6 tons, and I doubt whether any continued observation on his part—a man of such experience and intelligence—would bring about the support of his theory.

Mr. MAILLOUX: I must repeat what I know to be facts. They are not mere theories or chimeras, but they are facts. Now, if you stop to reason for a little while you will readily see that when a motor is allowed to run very fast its counter electromotive force approximates very closely to its source of energy. Consequently the current through it is very small. If you put a force like a brake that tends to slacken that motor and gradually couple it with the driving axle, you will have a variable velocity ratio between the two, which ratio is gradually approaching unity. As you put on a greater and greater effort you are slacking the motion of the armature and getting the benefit of its momentum, while at the same time the current is increasing through it, and in that way you have the most gradual putting on of the current that you can hope for. I have seen the experiment made so many times that I for my part do not doubt it any more.

The PRESIDENT: There being no further discussion, I will simply ask Mr. Reckenzaun to make one or two closing remarks.

Mr. RECKENZAUN: I was merely going to reply to Mr. Mailloux. On the very first car which I constructed in 1882, which was worked by storage batteries, I used the momentum not only of the armature of the motor, but also the momentum of a fly-wheel, which weighed between three and four hundred weight. I put the fly-wheel upon the countershaft, and I used that gearing which I sketched on the board to-night—that peculiar gearing with the disks and a wedge-shaped band. I employed the friction clutch. I thought that by starting the motor to its full speed, and with a heavy fly-wheel, that that would be a great advantage in the starting of the car, but I was greatly disappointed. The car started with a jerk, and when I did away with the fly-wheel I found that the car started with the greatest of ease, and I believe from actual experience which I have had in this direction, that it is far better to start without the momentum of the armature or the momentum of any substance connected with the armature. It is perfectly natural that an electric motor must start gradually. Take the motor off the car altogether and put it upon a table and send through it any current from any battery you like, or from any source of energy you like—50 volts, 100 volts, or 500 volts—and you will find that the armature cannot start suddenly. It requires a few seconds to take up its speed, and therefore it is perfectly natural that a car propelled by electric energy must start gradually. Our worthy president has requested me to make some concluding remarks, but the hour is late, and I believe gentlemen, you will be very glad to get off. I have nothing more to say. I have been exceedingly interested in the various remarks which have been made to-night, and I must own that I have learned a great deal. With regard to the general application of electricity to street car propulsion, as Mr. Pendleton has pointed out very forcibly, there is a very great future in store for us, and the time is very near when horses on street cars will be entirely abandoned. We have, I might say, almost passed the experimental stage and we are now entering the more profitable stage of manufacturing and supplying street railways with electric motors. The advantages in electric motors are not only economy, but cleanliness and great saving of space at the depots and great saving of space on the streets. If you take crowded streets like Broadway, New York, and many other thoroughfares where every square inch of space you might save in the street is of value, if you do away with horses you save in length about 12 feet, and in width, of course the width of the track. Now, it would seem ridiculous for me to make such a remark, but if there are hundreds of cars running in a crowded street it makes many thousand square feet of space saved, and in that space other vehicles can pass. Another great advantage in electrical propulsion will be (apart from economy which is certain to be a result) that we shall be able to travel at a greater speed. Horses cannot pull a car at a greater speed than six miles an hour. The average speed of all the horse cars in America and Europe is five miles an hour, including stoppages. Now, if we can travel at the rate of eight or ten miles an hour a great deal of time will be saved and passengers will avail themselves more of the new mode of traction. They will save a great deal of time. The traffic is constantly increasing. I have heard recently that the street car traffic of New York alone has increased in the last ten years 50 per cent. If it increases in the next ten years 50 per cent. again it would be impossible to cope with the traffic if we employ horses at all. The elevated railroads, it appears, are doing a large amount of business—almost as much as they are capable of handling, and the only loophole, it seems to me, out of the difficulty, is either by building underground railways or by propelling the street cars at a greater speed, so that the same number of cars will carry double the number of passengers in the same time. With these remarks, gentlemen, I close, and I thank you very much for your very kind attention.

Mr. WHEELER: I move a vote of thanks to Mr. Reckenzaun for his interesting and instructive paper.

The motion was seconded by Mr. WETZLER, and carried.

Mr. MAILLOUX: If I may be allowed to express another thought I would like to say that I wish we also had a medal, that we might be able to give it to Mr. Reckenzaun, because in the discussion of the subject that he has brought before us this evening, I for one, and doubtless a great many others who are here—particularly those of us who are especially interested in the subject—feel that we have been dealing with the work of a master—a man who is eminent in his work and from whom we can all learn deep and valuable lessons. That is the reason, gentlemen, why I feel that we also ought to have given Mr. Reckenzaun a medal or some other substantial recognition of the valuable work that he has placed before us.

Mr. JAMES D. REID: I am not able to express myself in scientific terms, but I think our good friend here has struck a strong feature of human nature, which convinces me that he has also struck the right vein in science. We all know that human life is a life of friction, that life is a struggle all the way through, even with the help of the best of food and the best of wine and the best of Scotch whisky. It is a struggle after all, and, gentlemen, I appeal to you, if, after life has done its best, the worm does not triumph in the end.

The meeting then adjourned.

NEW ELECTRIC LIGHT INSTALLATION.

THE new premises of Messrs. Lloyds, Barnett and Bosanquet, the firm of bankers, of 72, Lombard Street, have been furnished by Messrs. Latimer Clark, Muirhead and Company, Limited, with 270 lamps of eight and 16-candle-power, and the installation is worthy of inspection by those interested. On Monday the bank will open for business, but the lights have been in working condition for the last fortnight. Preparations have been made for a considerable extension of the system; it is proposed to raise the total number of lamps to 500 or more when all the offices comprised in this spacious building find occupants; but in the meantime the supply is limited to those rooms in the basement and on the ground and first floors, which are exclusively in use by the proprietors. The large hall, which constitutes the principal apartment wherein the general business of the bank is transacted, is supplied with 79 lamps, in addition to two electroliers of ten lights each, and the board room possesses 18 lamps, of which two are of 16 candle-power, and the remainder of eight each. The directors' room, with its attendant waiting room, consumes 17 lamps of eight candle-power, and the manager's room and the hall are each furnished with eight lamps of this size, and the luncheon room with six. The secretary's office possesses ten lamps of 16-candle power, and eight of the same power light the stock department. The strong rooms, wherein are to be preserved the bullion, plate, books, and securities of the bank contain nine lamps of the larger size. The remaining lamps have been distributed among the various corridors and the lavatories in the basement, the whole installation thus constituting one of the most perfect of its kind, and embracing all known improvements.

The power requisite to light the 270 lamps at present in operation, is derived from E.P.S. accumulators (of the Drake and Gorham design and made by Elwell-Parker & Co.) charged from a Westminster dynamo, driven by a 14 H.P. Crossley "Otto" gas engine, of 14 nominal, 33 indicated, horse-power, up to a maximum speed of 1,200 revolutions. There are 104 cells in all, of the 31 L type. The engine also drives a Blackman air-propeller in the battery room, designed to remove the fumes emanating from the accumulator cells.

As an example of neat and effective work the switchboard will bear close inspection, as also the cable main leads, which form nine distinct circuits of each sign, the positive being well separated from the negative group, and each lead being isolated from its neighbours in grooved boarding throughout. Ayrton and Perry's voltmeter and ammeters are attached to the switchboard with a special ammeter for testing the mains separately, and the entire system is perfectly under the control of one man, inasmuch as the power is passed through the nine separate channels all terminating on the switchboard.

Platforms have been constructed in readiness for the second engine and dynamo which will be fitted as soon as the offices now "to let" on the upper floors find tenants.

The accumulators when fully charged are sufficient to supply the whole installation for a period of 10 hours, which in practice would probably mean at least 12 hours, as the entire system of lamps would seldom be in use throughout the guaranteed time.

The engineers are Messrs. Henry Lea and Thornberry, of Birmingham, to whose drawings and specifications the whole of the work has been carried out by contract down to the smallest detail.

Telephonic Extension at Brighton.—The United Telephone Company is now engaged in completing the line connecting Brighton with Lewes and Eastbourne. Many wires have been carried over the house-tops at Lewes, where it is proposed to open a call office at the Star Hotel.

PROF. FORBES'S ELECTRICAL TABLES.

TABLE A.

SECTION IN SQUARE CENTIMETRES PER 100 AMPERES.

Cost per H.P. per annum.	·4	·6	·8	1·0	1·1	1·2	1·3	1·4	1·5	1·6	1·7	1·8	1·9	2·0	2·2	2·4	2·6	2·8	3·0	3·5	4·0	Cost per H.P. per annum.
20	30	13	7·5	4·8	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	20
40	60	27	15	9·6	7·9	6·6	5·7	4·9	...	...	...	...	...	...	...	...	...	...	...	...	...	40
60	90	40	22	14	12	10	8·5	7·3	6·4	5·6	5·0	...	...	...	...	...	...	...	...	...	...	60
80	...	53	30	19	16	13	11	9·8	8·5	7·5	6·6	5·9	5·3	4·8	...	...	...	...	...	...	...	80
100	...	67	37	24	20	17	14	12	11	9·4	8·3	7·4	6·6	6·0	4·9	...	...	...	...	...	...	100
120	...	80	45	29	24	20	17	15	13	11	9·9	8·9	7·9	7·2	5·9	5·0	...	...	...	...	...	120
140	...	93	52	34	28	23	20	17	15	13	12	10	9·1	8·4	6·9	5·8	5·0	...	...	...	...	140
160	...	...	60	38	32	27	23	20	17	15	13	12	11	9·6	7·9	6·6	5·7	4·9	...	...	...	160
180	...	...	67	43	36	30	26	22	19	17	15	13	12	11	8·9	7·5	6·4	5·5	4·8	...	...	180
200	...	...	75	48	40	33	28	24	21	19	17	15	13	12	9·9	8·3	7·1	6·1	5·3	...	...	200
250	...	...	93	60	49	42	35	31	27	23	21	19	17	15	12	10	8·8	7·6	6·6	5·0	...	250
300	...	...	...	72	59	50	42	37	32	28	25	22	20	18	15	13	11	9·2	8·0	5·9	...	300
350	...	...	...	84	69	58	49	43	37	32	29	26	23	21	17	15	12	11	9·1	6·8	5·2	350
400	...	...	...	96	79	66	57	49	42	37	33	30	26	24	20	17	14	12	11	7·8	6·0	400
450	...	...	...	...	89	75	64	55	48	42	37	33	30	27	22	19	16	14	12	8·8	6·9	450
500	...	...	...	...	99	83	71	61	53	47	41	37	33	30	25	21	18	15	13	9·8	7·7	500

N.B.—The cost per horse-power per annum must be taken in the same units as the cost of conductor in Table B. Shillings, francs, marks, or quarter-dollars, are the most convenient.

TABLE B.

COST PER ADDITIONAL KILOGRAMME OF COPPER.

Rate of Interest.	1·2	1·3	1·4	1·5	1·6	1·7	1·8	1·9	2·0	2·5	3·0	3·5	4·0	5·0	6·0	7·0	8·0	Rate of Interest.
5	5·3	5·8	6·2	6·7	7·1	7·5	8·0	8·4	8 9	11	13	16	18	22	27	31	36	5
7½	8	8·7	9·3	10	11	11	12	13	13	17	20	23	27	33	40	47	53	7½
10	11	12	12	13	14	15	16	17	18	22	27	31	36	44	53	62	71	10
12½	13	14	16	17	18	19	20	21	22	28	33	39	44	56	67	78	89	12½
15	16	17	19	20	21	23	24	25	27	33	40	47	53	67	80	93	—	15

N.B.—Cost of conductor must be taken in the same units as the cost per horse-hower per annum in Table A. Shillings, francs, marks, or quarter dollars are most convenient.

N.B.—If the cost of conductor is given in pounds sterling per ton, divide this number by 50 to obtain the result in shillings per kilogramme.

Example.—Conductor costs 2·0 francs per additional kilogramme of copper. Rate of interest is 10 per cent. The auxiliary number found from these numbers in Table B is 18. If a horse-power costs 250 francs per annum, looking along this row in Table A the auxiliary number 18 is between 1·8 and 1·9 square centimetres per 100 ampères.

MINERS' SAFETY LAMPS.

THE following correspondence has appeared in the *Times* since the publication of our article on Mining Accidents last week. Mr. C. Tylden-Wright, of the Priory Offices, Dudley, wrote:—"Mr. Ellis Lever has again called attention, through your columns, to the number of deaths from colliery accidents, which, he says, average 1,200 a year. The inspectors' reports since 1851 make the average 1,060, of which less than one-fourth (234) are from fire damp or explosions, and this number was further reduced last year to 129, or one death for 4,030 men employed. The proportion has been less in only four of the past 36 years. Mr. Lever urges the universal use of the electric light underground, forgetting that it would be absolutely useless for testing for gas, whether firedamp or chokedamp. All who work in or are responsible for the safety of fiery collieries will rejoice when electricians will provide a practicable lamp; but we all know how small a chance the delicate glass globe which surrounds the light would have in the showers of minute particles of rock and coal which are thrown off in cutting the coal, and from the movement of the men in contracted spaces. If there is any name that should be retained and immortalised in connection with coal mining it is that of Sir Humphrey Davy; and Mr. Lever and the miners' associations who would expressly exclude his lamp must be aware that it is still the most delicate lamp for testing for gas, and that there are large mining districts, such as South Staffordshire, in which candles are still used and lamps only required for testing purposes. In such districts the velocity of the air current does not approach 6 feet per second, which the Royal Commission names as the highest safe velocity for the Clanny or Davy. The only alteration which the House of Lords made to this clause of the Mines' Bill was to send it back to the Commons as originally drawn by the Home Secretary after conferences with the inspectors, the Mining Association of Great Britain, and deputations from the men, and it stands as follows:—'Wherever safety lamps are used they shall be so constructed that they may be safely carried against the air current ordinarily prevailing in that part of the mine in which the lamps are for the time being in use, even though such current should be inflammable' The clause is stronger and more general than if any particular lamps had been excluded, and any agent or manager who fails to provide such a lamp can be proceeded against for an offence under the Act. I have attended deputations to the Home Office on every Mines Act which has been passed since 1860, and I have never known a Home Secretary so anxious to combine safety with practicability as Mr. Matthews, or one more determined to hold the balance fairly between masters and men."

Major S Flood Page, manager and secretary to the Edison and Swan United Electric Light Company, wrote:—"There are few subjects of greater interest than the diminution of preventable accidents in mines referred to in Mr. Ellis Lever's letter in your issue of Saturday and in Sir F. Abel's of this day. Sir Frederick Abel says that Mr. Lever 'may be glad to know that there are mine-owners who are showing themselves, by hearty co-operation with and assistance of the designers of electric lamps, as eager for their introduction as he himself can possibly be.' Permit me to confirm this statement by informing you exactly how the question now stands. Hardly a day passes without my receiving some communication or being asked how the manufacture of miners' electric lamps is progressing. Mine owners and managers are most anxious to have an efficient electric safety lamp, produced at a reasonable price, placed in their hands. Mr. Swan read a paper before the mining engineers at Newcastle and elsewhere some time ago, and it is known in mining circles that we are engaged in the solution of the problem. In April last, having made the best miners' lamp we could, we were permitted by Messrs. Watts, Ward & Co., of Newport and Cardiff, to place our lamps in their pits at Risca for practical, regular, daily test. Mr. Williams and Mr. Wilkinson, the managers, were intensely interested in the trials, and on our arrival at Risca we received the warmest welcome from overlookers and the electrician of the collieries. The miners took to the lamp at once, and I heard that some of the men had said that if the owners did not give them our lamp they would pay for it themselves. But the practical tests followed. For many weeks the lamps were tried by all sorts and conditions of miners, and, guided by the practical experience of the manager and others, we made many alterations of detail, and at the end

had, undoubtedly, the best and safest miners' lamp that had ever been seen. The result of these trials under the exact conditions of the daily routine of the pits, and under which the lamps will be in regular use, has been that the enterprising owners, Messrs. Watts, Ward & Co., have ordered us to manufacture 2,400 electric safety lamps, with a view to the supersession of all the existing lamps throughout their extensive South Wales collieries. Nearly, if not quite, the first to use the electric light at their pits, they will undoubtedly be the first to give a portable electric safety lamp to every one of their underground men. That this will materially diminish the risk of accident from explosion is believed by every one who has studied the subject. Some of those who are directly interested in the introduction of the electric lamp into mines ask us from time to time to lend or sell them samples of the lamps, in order that they may be submitted to mining engineers or scientific experts, and I have heard it said that we move very slowly in the matter. It is no light thing to revolutionise mine lighting, and the task of producing an efficient, safe, practical lamp, giving sufficient, but, as Sir F. Abel suggests so wisely, not too much light, has taxed the brains of our scientific and working staff. Everything is new; fresh machinery has had to be designed and made, and many difficulties have from time to time arisen. So many mistakes have been made in matters electrical from being in too great a hurry, that we have preferred being charged with slowness rather than run any risks. I am glad to say that all but minor difficulties have been overcome, and the first batch of 600 is fast approaching completion. As soon as they are finished, we shall be able to show mine-owners and managers the lamps at 13, Albert Mansions, and we shall have a number ready for Sir Frederick Abel when he reads his paper at the Institution of Civil Engineers next month. I may add that I gave notice, some months ago, to Mr. Ellis Lever, that we wished to claim his prize of £500 for the best and safest miners' electric lamp. I trust that you will pardon the length and nature of these remarks, but I know no other way of showing that we are doing all in our power to place in the hands of mine-owners a lamp such as Mr. Ellis Lever has so long been demanding, and of confirming Sir Frederick Abel when he says that great progress has been made. I hope and think that colliery owners generally will follow the example of Messrs. Watts, Ward & Co., and I have much confidence that the risk of explosions will be forthwith reduced by the general adoption of this electric safety lamp."

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

(Specially Reported for the "Electrical Review.")

THE GENERAL THEORY OF DYNAMO MACHINES.*

By EDWARD HOPKINSON, D.Sc.

(Section A.—Mathematical and Physical Science.)

Tuesday, September 6th, 1887.

USING the term "dynamo" in the widest possible sense, including under it all machines for the conversion of mechanical forms of energy into electro-magnetic, and electro-magnetic into mechanical, there are certain characteristics common and essential to all types of such machines, whether they be known as magneto machines, alternate current machines, or continuous current machines, either compound, shunt, or series wound, and of the drum, ring, or disc type. It is therefore possible, up to a certain point, to construct a theory of dynamo machines which is perfectly general in its application. The object of the present paper is to trace briefly the outlines of such a theory, and to indicate how the consideration of specific types of machines can be developed therefrom, and in what direction research is required to elucidate some points still obscure. A dynamo consists essentially of two closed circuits or "tubes," in both of which there is a displacement of the nature of a flux dependent upon the relative motion of the two circuits. We may call one of these the "magnetic circuit," and the other the "electric circuit." Either or both of these may be in motion; but as we are concerned only with the relative motion of the two, we may for convenience (as, in fact, is usually the case), regard the magnetic circuit as fixed, or displaced only by the reaction of the electric circuit upon it, and consider the latter only as moving under external forces, whether electric or mechanical. The flux along the magnetic circuit is called the "magnetic induction," which is a vector or directed quantity, requiring for its definition reference to co-ordinate axes. It is subject to the fundamental condition known as the "solenoidal condition," or "equation of continuity," which may be expressed in words "that the flux across all sections of the tube is the same," or otherwise "the induction through any surface bounded by a closed curve depends only on the form and position of the closed curve, and not on that of the surface itself." The flux along the second circuit is called the "electric current," and is also a vector quantity, subject to the solenoidal condition. Neither circuit is necessarily bound by the limits of the machine, and both may be and generally are sub-divided. Both these fluxes are produced by corresponding forces, called respectively "magnetic force" and "electromotive force," which likewise are vector quantities, but are defined by reference to a line instead of by an area, as is the case with the fluxes. (Maxwell. "Treatise on Electricity and Magnetism," Vol. I., page 10.) The solenoidal condition for magnetic induction is a direct deduction from Coulomb's original experiment, verified by all subsequent observations in magnetism. We now require to know the relation between each force and its corresponding flux. Let us first inquire into the relation between the magnetic induction (B) and the magnetic force (H). Such a relation may be expressed by the general equation

$$B = f^{-1}(H).$$

The form of the function depends upon the medium in which the tube is drawn, and also upon the physical conditions of the medium. For air and all other gases, and generally for all substances classed as "non-magnetic," it is a linear function possessing one co-efficient or constant only. For such substances the equation may be written

$$B = \mu H.$$

Since the numerical definition of H is at our disposal, we may so define H that μ is unity for all the substances above-referred to, and write

$$B = H.$$

For iron, and generally for all magnetic substances, H is not a linear function of B, and its expression will involve several constants depending upon the medium, and such physical conditions as temperature and strain, and its previous history. The determination of the form of the function for iron in particular has been the subject of a great number of experiments, but no general expression has yet been discovered, and it has usually been found most convenient to record the experimental results in the form of a curve referred to rectangular axes, in which the ordinates represent magnetic induction and the abscissæ magnetic force. Such curves have been fully investigated for iron of various composition, and under varying physical conditions, among others particularly by G. Wiedemann (Die Lehre vom Galvanismus, Vol. II., page 340, & sequor), Rowland (*Phil. Mag.*, August, 1873), Carl Barus and Vincent Strouhal (Bulletin of the United States Geological Survey, No. 14, 1885), J. Hopkinson (Philos. Trans. of of R.S., Part II., 1885), J. A. Ewing (Philos. Trans. R.S., Part II., 1885, and Part II., 1886, and Proc. of R.S., Vol. XLII., page 200, 1887). By reference to these memoirs it is now possible to construct the curve with fair accuracy for iron of any known composition. For convenience we may express the curve by the equation

$$B = \mu H,$$

μ is then the tangent of the angle which the tangent to the curve makes with the axis of x. It has received various names; by Sir William Thomson, "permeability" (Reprint of Papers on Electricity and Magnetism, Vol. II., page 54); by Maxwell, "coefficient of magnetic induction" (Treatise on Electricity and Magnetism, Vol. II., page 54): and, again, "magnetic inductive capacity" (Vol. II., page 243).

Secondly, we require to know the relation between the E.M.F. and current. This is well known to be expressed by a linear relation, known as Ohm's law, involving one constant coefficient only, universally designated the "resistance."

$$E = R C.$$

E being the E.M.F., and C the current. As far as all experimental evidence goes, R and the reciprocal of μ possess the same two characteristics, viz., that for any given substances in any defined physical condition they are proportional to the length of tube considered, and inversely proportional to its cross section; μ may therefore without impropriety be called the reciprocal of the "magnetic resistance," but as expressing this analogy only. It must be distinctly remembered that for magnetic substances there is no such relation as Ohm's law.

Having now defined the relation between the fluxes and their corresponding forces, it remains to consider the relation between the fluxes themselves, dependent upon the relative motion of their circuits. This may be expressed in various ways, all of which are the expressions of Faraday's well-known law: (1) The line integral of the E.M.F. round the electric circuit is the rate of decrease of the surface integral of magnetic induction through any area bounded by the circuit; or (2) the time integral of the total E.M.F. round the electric circuit together with the surface integral of the induction through the circuit is a constant quantity. Again, since the surface integral of any vector over any surface which satisfies the solenoidal condition can be expressed by a line integral round any closed curve bounding the surface, a new vector may be introduced called the "vector potential" of magnetic induction, which is such that its line integral round any circuit is equal to the surface integral of induction over any surface bounded by the circuit. Also the time integral of the E.M.F. in any circuit is the electro-magnetic momentum. Hence Faraday's law may be expressed (3) The electro-magnetic momentum of a circuit is the line integral of the vector potential round the circuit (Maxwell, Vol. II., pp. 28 and 234).

Excluding for the moment the consideration of magneto machines with permanent magnets, and of machines in which iron plays no part whatever, we may more particularly consider that class of dynamos in which the magnetic field is produced by the use of iron excited by a current; and we then require to know the relation between the current and the induction in the magnetic field produced by the current. Faraday showed that the

* Taken as read.

magnetic field in the neighbourhood of an electric current is the same as that of a magnetic shell bounded by the circuit of the current, and has therefore a similar magnetic potential. This is expressed by saying (4) that the line integral of magnetic force round any closed curve is zero, provided the closed curve does not surround the electric current, and if the current passes through the closed curve, then the line integral is proportional to the number of times it passes through, and is equal to $4 \pi n c$, where c is the current and n the number of times it passes through the closed curve.

If we take the magnetic units as fundamental, the propositions (1) and (4) define the units of E.M.F, and current. On the other hand, if we start with the arbitrary units of E.M.F. and current, based on quite other considerations, the propositions define the units of magnetic induction and magnetic force in terms of these.

We have now the materials for a complete investigation of a dynamo of any given configuration and constructed of iron, whose magnetic qualities are known. It is required to determine the E.M.F. and current in the electric circuit, as its configuration relative to the magnetic circuit is changed by the application of external forces, and as the magnetic forces in the magnetic circuit are changed either by external electro-magnetic forces or electro-magnetic forces derived from the current circulating in the electric circuit. The magnetic circuit consists in general of four parts: (1) The magnet limb, which is surrounded by coils of wire, through which the exciting current is passed, which may be derived either from external sources or may be part of the electric circuit of the machine. (2) The field pieces, or the extended polar extensions of the magnet limb, embracing the armature. (3) The air space being the necessary interval between the iron of the pole pieces and the iron of the armature, or in cases where the armature contains no iron, the interval between the opposed pole pieces. This interval may be an entirely free air space or partially occupied with other non-magnetic matter, according to the particular type of machine. (4) The armature, or that part of the machine carrying that portion of the electric circuit which is subject to displacement under external forces. There may be other subsidiary portions of the machine, *e.g.*, the magnet limb may be divided into one or more portions connected by yokes, but as these may be treated in exactly the same way as the pole pieces they do not require special consideration. Again, the magnet limb may be divided so as to form several magnetic circuits, each of which may be considered independently. In alternate current such sub-division is universal, and is not infrequent in continuous current machines.

The magnetic circuit is thus subject to magnetic forces due to the current in the armature and the current round the magnet limb. We must therefore, in the general case, take these as two independent variables, which we may denote by C and c. Now, it may be assumed with sufficient accuracy that in the magnet limb the boundaries of the tube of magnetic induction are coincident with the boundaries of the iron, and the cross section of the tube the same as the cross section of the iron. Outside the limb a portion of the lines of force will complete a magnetic circuit through external space, and will not enter the pole pieces. The extent of this leakage or induction, from which no useful effect is obtained, depends upon the configuration of the machine and the degree of saturation of the iron, and could be calculated therefrom; but as it can be experimentally determined for any machine with great ease, it is unnecessary to consider it further, and we may regard the total induction in the magnet limb as greater than the induction in the pole pieces in a constant ratio, which we will denote by ν_1. It is usual to construct the pole pieces of large section compared with the magnet limb, and hence the section of the pole pieces may again be taken as the section of the tube of induction; but as the lines of force leave the pole pieces to cross the air space, we cannot ascribe any boundary to the tube, but in every machine a portion only can pass through the armature, and part must pass from one pole piece to the other by lines external to the armature. Moreover, the relation between the two parts will not be a constant one, unless the magnetic forces in the armature are constant, which can never be the case. It is therefore necessary to consider the tube of induction, which crosses the air space and enters the armature, as a variable portion of the whole tube, the variation depending upon the magnetic forces in the armature. We may denote the ratio of the induction through the pole pieces to the induction through the armature by ν_2. Knowing now the components of the magnet circuit, we can determine the magnetic forces in the several parts, and hence obtain the induction in the tube. Let A_1 be the cross section of the magnet limb, l_1 its length; A_2 the cross section of the pole pieces, l_2 the mean length of the tube therein; A_3 the cross section of the air space, comprising all the space through which the lines entering the armature pass, l_3 its length; A_4 the cross section of the iron of the armature (if it contains iron), and l_4 the mean length of the tube of force therein. Then the line integral of magnetic force taken round the circuit is:—

$$\frac{1}{\mu_1} l_1 \frac{\nu_1 \nu_2 \mathrm{I}}{A_1} + \frac{1}{\mu_2} l_2 \frac{\nu_2}{A_2} + \left(\frac{l_3}{\mu_3 A_3} + \frac{l_4}{\mu_4 A_4} \right) \mathrm{I}$$

the μ's being the coefficients of magnetic induction for the several portions of the circuit. For air the coefficient is unity, hence $\mu_3 = 1$. I is the total induction in the armature, which is assumed to be uniformly distributed over the tube. The integration has extended along the tube only which passes through the armature, and hence the forces along the portions of the whole tube which pass outside the machine do not appear. Now the magnetic circuit is cut by the current in the magnet coils and the current in the armature. Let n_1 be the number of times it is cut by the former, n_2 by the latter. Then

$$\frac{1}{\mu_1} l_1 \frac{\nu_1 \nu_2 \mathrm{I}}{A_1} + \frac{1}{\mu_2} l_2 \frac{\nu_2 \mathrm{I}}{A_2} + \left(\frac{l_3}{A_3} + \frac{1}{\mu_4} \frac{l_4}{A_4} \right) \mathrm{I} = 4 \pi (n_1 c + n_2 \mathrm{C})$$

It must be noted that the direction in which the circuit is cut by c and C is in both cases taken to be positive. Referring to three rectangular axes and measuring the induction along the axis of z, the current round the magnets along the axis of x, and that in the armature along the axis of y, the above equation may be written

$$l_1 f_1 \left(\frac{\nu_1 \nu_2 z}{A_1} \right) + l_2 f_2 \left(\frac{\nu_2 z}{A_2} \right) + l_3 \frac{z}{A_3} + l_4 f_4 \left(\frac{z}{A_4} \right) = 4 \pi (n_1 x + n_2 y)$$

This represents a surface the ordinate at any point of which is the induction through the armature. Such a surface was first described by Dr. John Hopkinson (Lecture before the Inst. of C. E., April, 1883), and is called the "characteristic surface." It must be remembered ν_1 is a constant coefficient, or may be taken as such with sufficient accuracy, but ν_2 is not constant. It is unnecessary to consider further its general form, as it may better be determined in connection with the particular type of machine under consideration. $f_1 f_2 f_4$ would be the same functions if the quality of the iron were the same in the several portions of the machine.

Having obtained a general expression for the induction in the armature, the electromotive force in the electric circuit, when displaced, can be deduced by Faraday's law.

Consider now the application to alternate current machines. Such machines are usually multipolar. In machines of the disc type the number of poles is even, and the armature is divided into sections corresponding to the number of poles, and revolves uniformly between them. The tube through any one pair of opposed poles and back through another need only be considered, and the total effect of the machine obtained therefrom by summation. Suppose the iron of both magnets and armature so arranged that no currents are induced therein. There is then only one electric circuit to deal with. The whole current in one section of the armature cuts the magnetic tube passing through the section, as many times as there are convolutions. Let m be the number of convolutions. The current, x, round the magnets is usually derived from independent sources, and maintained constant. For each such constant value the characteristic surface becomes a curve giving the relation between the induction through the armature and the current in it. The areas A_1, A_2, and A_4, and the lengths l_1, l_2 l_3, and l_4 are constant, but the area A_3 is a periodic function of the time, and can be expressed by a series of cosines, the coefficients of the series being determined by Fourier's theorem from the dimensions of the machine. The general consideration of the form of ν_2 has been worked out by Dr. J. Hopkinson (Proc. R.S., 1887), and need not be referred to further. The induction is a function of the time, but as an example consider its value at that epoch when the cores of the armature are exactly opposed to the pole pieces.

$$\frac{l_1 \nu_1 \nu_2 \mathrm{I}}{\mu_1 A_1} + \frac{l_2 \nu_2 \mathrm{I}}{\mu_2 A_2} + \left(\frac{l_3}{A_3} + \frac{l_4}{\mu_4 A_4} \right) \mathrm{I} = 4 \pi n_1 c - 4 \pi m \mathrm{C}$$

Since the coefficients are all determinate by measurement or experiment, I is obtained in terms of c and C. Assume that, instead of continuous rotation of the armature, the action of the machine is such that each core of the armature is moved periodically in an infinitely short time from between one pair of poles to the next. Let T be the periodic time, E the electromotive force, then

$$\mathrm{E} = m \frac{2 \pi}{\mathrm{T}} \mathrm{I}.$$

Hence E is determined in terms of c and C. E is here the maximum E.M.F. The E.M.F., as measured by a Cardew voltmeter or equivalent instrument, will be $\frac{1}{\sqrt{2}}$ of the maximum. If the equation of the characteristic be differentiated with regard to the time, we shall obtain an equation of the form

$$\mathrm{A} \dot{y} + \mathrm{B} y = \text{periodic function of } t,$$

when B is constant and A is a periodic function of t, but usually assumed to be constant, and called the "self-induction" of the machine. In the case of an alternate current machine there are usually other magnetic forces acting upon the electric circuit external to the generating machine. For instance, the electric circuit may contain a transformer, or a second machine inserted as a motor, or an arc lamp in which there is a constant E.M.F. changing sign with the current. It is not then sufficient to consider the magnetic tube within the machine only, but the effect of all other tubes which are cut by the circuit must be included, and the characteristic surface of the whole system obtained by summation. These cases have been worked out, taking A as by Dr. J. Hopkinson. (*Journal of Telegraph Engineers*, 1884.)

Now consider the application to continuous current machines. With the exception of certain types of dynamos, like that of Prof. Forbes, or the cylinder dynamo of Dr. Werner Siemens, in general no current continuous in direction can be obtained by continuous

rotation of any part of the electric circuit, unless arrangement is made for reversing the current at a certain stage of each revolution. If the rotating part contained one section only, the current, though continuous in direction, would oscillate from zero to its maximum. To avoid this the electric circuit is divided into a number of sections, arranged symmetrically on the armature, the current in one or two of which only is reversed at a time. If the number of sections be even and equal to $2\ m$, one half will be in series, and one half the total current will pass through each half, except at the instant of commutation. At such time two sections are short circuited, and form complete circuits in which the current will be determined by the induction through them at the time; and the number of sections in series will be $m - 1$. If the number of sections be odd and equal to $2\ m + 1$, one section only will be commuted at a time, and at that instant there will be m sections in series. At other times there will be $m + 1$ sections in series on one side and m on the other, and consequently there will be a superposed current flowing through the armature only, due to the inequality in the number of sections in series in the two halves, In one revolution of the armature the tube of induction through it will be cut four times by each section, and if the plane of commutation is symmetrical with regard to the tube of induction the current in one half the sections will cut it in the opposite direction to that in the other half. In this case, $n_2 = o$. But any displacement of the plane of commutation from the symmetrical position will cause the current in a greater number of sections to cut the tube in one direction than in the other. Let λ be the angular advance of the plane of commutation, and m the number of sections in the armature; then $n_2 = \frac{\lambda\, m}{\pi}$. The value of λ may be fixed for any given machine, or varied at pleasure, or may be determined to avoid sparking at the time of commutation of a section. The general discussion of the value of λ to effect this has not yet been attempted. For the present λ must be regarded as independent. The general equation of the characteristic surface becomes for a continuous current machine,

$$l_1 f_1\left(\frac{\nu_1\ \nu_2\ z}{A_1}\right) + l_2\, f_2\left(\frac{\nu_2\, z}{A_2}\right) + l_3\ \frac{z}{A_3} + l_4\, f_4\left(\frac{z}{A_4}\right) = 4\,\pi\, n_1\, x - 4\,\lambda\, m\, y$$

λ being reckoned positive when the displacement is in the direction of rotation.

If no current passes through the armature $y = o$ and ν_2 may be taken as constant and determined by experiment. The equation may then be written

$$l_1 f_1\left(\frac{\nu_1\ \nu_2\ z}{A_1}\right) + l_2\, f_2\left(\frac{\nu_2\, z}{A_2}\right) + l_3\ \frac{z}{A_3} + l_4\, f_4\left(\frac{z}{A_4}\right) = 4\,\pi\, n_1\, x$$

which is the equation to the characteristic curve of a shunt wound or separately excited machine, and determines the induction for all values of the exciting current. Having determined the characteristic when $y = o$ the characteristic surface can be determined therefrom by considering the form of ν_2. (See J. and E. Hopkinson. *Trans. of R. S.*, Part I., 1886, p. 334.)

It has been assumed that the sections of the armature are the only conductors in the field, or that the armature is so constructed that no currents circulate in the iron. This in the best machines is only partially attained. The effect of such currents on the characteristic surface is the same as increasing the current in the armature. If the lead is negative the induction is increased both by the current in the sections of the armature and in the iron; but such a negative lead must give rise to destructive sparking, as the sections will be commuted in a strong field.

LEGAL.

Pearson v. Maxim-Weston Electric Company.—In the Glasgow Sheriff Court, last week, an action by Mr. Ebenezer Westmoreland Pearson, electrical agent, 23, Wilson Street, Hillhead, was heard against the Maxim-Weston Electric Company, Limited, Buchanan Street. Pursuer stated in his petition that, on May 19th, 1886, he was appointed agent of the company for Glasgow and the surrounding district, the engagement to last for six months. He was to devote his whole time to the business, to receive a salary of £5 a week, with necessary travelling expenses, and a commission of 2½ per cent. on the gross amounts received for orders obtained by him. At the time of his engagement he was resident in London, but he took an office in Glasgow in his own name for a year from Whitsunday, 1886, and furnished it at a cost of £30, of which Mr. Hugh Watt, M.P., the chairman of the company, subsequently allowed him £20, which pursuer received. At the request of Mr. Watt, pursuer, in the middle of July, 1886, went to Dundee to push business, and expended £10 in travelling expenses. On July 23rd he returned to Glasgow, and found that defenders had taken possession of his office, substituted another name for his own, and seized his papers. He was then handed a letter from defenders, dated July 19th, 1886, terminating his engagement. Pursuer claimed £500 as damages for unwarrantable ejectment from his office and dismissal, and as an estimate of the salary and commission which he would have earned during the four months of his engagement which were unexpired, also £15 for salary due, and £10 for travelling expenses. The defenders denied generally the pursuer's statements, and pleaded that he failed to comply with the orders of the board, and absented himself from business without authority. Mr. Hugh Watt, M.P. for Camlachie, the chairman of the defenders' company, was examined. At the close of the proof his Lordship made avizandum of the case.

NOTES.

Cathcart Electric Lighting.—It is to be regretted that Mr. Kennedy has seen fit to discontinue the electric lighting of the railway station and shops, &c., at Cathcart, seeing that his system of lighting by transformers was working so well and giving so much satisfaction to all concerned. Nor can we help thinking that if vigorously pushed in a commercial sense a very large number of private renters could have been obtained, both at Cathcart and Mount Florida.

Electric Light in a Kimberley Theatre.—The first theatre to adopt the electric light in South Africa is the Queen's at Kimberley. The plant consists of a 10-H.P. nominal single cylinder engine by Ransome, Sims & Co., a shunt-wound dynamo machine of the Anglo-American Brush Corporation's manufacture, capable of running 130 incandescent lamps of 16 C.P. each, and a set of 34 storage cells manufactured by the E.P.S. Company. Great satisfaction is felt with the installation, which was fitted up under the superintendence of Mr. R. L. Cousens, electrician to the Borough of Kimberley.

The City Electric Lighting. — The St. Saviour's District Board of Works has acceded to the application of the Anglo-American Brush Electric Light Corporation for permission to lay down electrical mains under the footways of Blackfriars Road for the purpose of supplying a portion of the City with electricity, on condition that the company shall supply the electric light to the residents of Blackfriars Road on the same terms as they supply the current elsewhere.

Electric Lighting of the President's Train.—Some fuller particulars than those given in our last week's issue have reached us, from which we learn that the three cars of the train are known as the "Alafretta" (a composite car), the "Velasco" (a sleeper), and the "P.P.C."—by which initials Mr. Pullman's private car is known. In the forward end of the composite car is a "Western Electric" constant current series dynamo, commercially rated as a two-light machine. It is run by a Payne upright engine, which takes steam from an upright boiler of the same make. Under each car there is a storage battery of 32 cells of the "23 C" type, of the Electrical Accumulator Company's make. The charging wires from the dynamo to the storage batteries are run over the roofs of the cars. The wires are in the form of a double cable, and connection from one car to another is made through the medium of a double spring socket and hooks. In the "P.P.C." and "Velasco" there are 26 16-candle-power Edison lamps, and in the "Alafretta" there are 17 lamps. Edison fuse boxes are used. The switches are so arranged that the operator can charge any one of the batteries, and the switches, controllable by the porter, are so arranged that the lights in the body of the cars can be turned on or off without disturbing those in the vestibules of the cars.

The Telephone in Hawick.—Last week Mr. A. R. Bennett, general manager of the National Telephone Company, Limited, had a meeting with a number of gentlemen in Hawick, with a view to introducing a telephone exchange in that town. It was mentioned that Hawick was about the only large town in Scotland without a telephonic service.

Telephonic Extension at Southampton. — Encouraged by the support accorded to their exchange at Southampton, which although only started sixteen months ago now numbers 73 subscribers, representing nearly every trade and interest, the Western Counties and South Wales Telephone Company has decided upon establishing a public call-room, where for a small fee of twopence, three minutes' conversation can be obtained with any firm connected. The call-room is to be established in close proximity to the most important thoroughfares. It is likely that before long a call-room will be started at Shirley, a suburb of Southampton, and the company has in comtemplation the erection of a trunk line between Winchester and Southampton.

A Telephone Exchange at Jersey.—The Western Counties and South Wales Telephone Company has afforded another proof of its activity by establishing a telephone exchange at Jersey where it is likely to gain a good deal of support. In course of time, no doubt, there will be an electrical link between Jersey and the other Channel Islands.

A Military Telephone Exchange.—Recognising the valuable time-saving qualities of the telephone, the military authorities at Aldershot have just opened an exchange, the headquarters being at the offices of the Assistant Adjutant-General. It is confidently anticipated that this welcome innovation will save the employment of a large number of orderlies, many of whom could be much more profitably engaged in connection with their own regiments. At the same time the exchange will ensure a much more rapid and certain means of inter-communication between the various military offices.

The Melbourne Telephone Exchange.—The Victorian Government has at length succeeded in effecting the purchase of the business of the Victorian Telephone Company. The price paid was £40,000.

Telegraph Communication with Paris. — From statistics published by the *Journal des Chambres de Commerce* we learn that Paris is telegraphically connected with foreign countries by 43 lines, distributed as follows: England, 12 lines to London; Germany, 10 lines, 4 to Berlin, 2 to Frankfort, and 1 each to Hamburg, Strasburg, Cologne, and Mulhouse; Austria, 3 lines, 2 to Vienna, 1 to Bregenz; Belgium, 4 lines, 2 to Brussels, 2 to Antwerp; Denmark, 1 line, Cable Fredericka-Calais; Spain, 1 line to Madrid; Holland, 2 lines to Amsterdam; Italy, 6 lines, 2 to Rome, 1 each to Florence, Turin, Genoa, and Milan; Switzerland, 4 lines, 2 to Geneva, 1 each to Basle and Berne.

The Atlantic Cable War.—Mr. T. De Castro, director of the Commercial Cable Company, has written to the *Times* to the following effect:—"I see it stated in the Money Market article of the *Times* to-day that 'the report that an agreement between the "pool" and the Commercial Cable Company has been come to, and that an advance in the tariff is imminent, seems to have some foundation.' I think it my duty to inform you that there is not the slightest foundation for any such report. There are no negotiations for an agreement, and in my judgment there is no probability of any advance in the tariff for a long time to come."

Tangiers Cable.—It is reported that the Morocco Government is energetically protesting against the continuation of this means of communication. Indeed, the prejudices against this cable service are so strong, that it would not be surprising were the Morocco Government to take some very decided action in the matter. This, we must state, is a French view of the matter, but how far it is justified by events, or to what extent it may be influenced by interested motives, we are unable to determine.

A New Voltmeter.—With reference to our note of last week, Mr. W. B. Esson writes that a voltmeter similar in principle to the one made by Messrs. Siemens Bros., was devised by him two years ago. It never got beyond the calibration stage, and pressure of other work relegated it to a shelf in the test room, where it has remained every since. A similar instrument was patented at a later date by Mr. Swinburne.

Flickering in Arc Lamps.—A correspondent writes: "On looking through recent numbers of the ELECTRICAL REVIEW, I observe a letter from Mr. C. L. W. FitzGerald, stating that there are to be seen at the Great Eastern Railway Station simplex arc lamps burning in parallel with the cheap form of Brush carbons. This statement is rather misleading, for at Liverpool Street the top carbons in the simplex lamps are cored and both are uncoppered. In the Brush lamps both are solid and coppered." What does Mr. FitzGerald say to this?

The "Great Eastern" Steamship. — The *Great Eastern* steamer was offered for sale by auction in Liverpool last week, by Messrs. Killock & Co. The attendance was large and the bidding brisk. The first bid was £15,000, which speedily mounted by one thousands to £21,000, at which figure the vessel was knocked down to Mr. Craik, manager to the late owner, Mr. Worsley, of Manchester, who gave £26,000 for the vessel 12 months ago. The sale was by order of the mortgagees.

Price of Gas.—The directors of the Gas Light and Coke Company have resolved, from and after the 1st of January next, to reduce the price of gas to private consumers on the north side of the Thames to 2s. 9d. per 1,000 cubic feet for common gas, and to 3s. 5d. per 1,000 cubic feet for Cannel gas. They have also resolved, from and after the same date, to supply the public lamps in the whole of their districts at 2s. 2d. per 1,000 cubic feet for common gas, and at 2s. 8d. per 1,000 cubic feet for Cannel gas.

The Racing Telegram Fraud.—Harry Wilks, the telegraphist who altered four telegrams containing the results of certain races, pleaded guilty at the Central Criminal Court on Monday, was sentenced to a month's imprisonment.

Paris and the Provinces.—From a French contemporary we learn that Paris is connected with Marseilles by six telegraph lines, with Bordeaux and Lyons by four each, with Lille, Havre, Brest, and Toulouse by three each, with Amiens, Montpelier, and Nantes by two each; all the other prefectures, with only a very few exceptions, have each one direct wire to Paris.

Personal.—Many of our readers are probably aware that Mr. C. H. W. Biggs, who has been for nearly ten years the editor of the *Electrician*, has resigned his connection with that journal. The circumstances which led to his resignation do not concern us and we therefore refrain from touching further upon the subject. Mr. Biggs has for some time held a large proprietary share in the *Electrical Engineer*, a journal hitherto published monthly, but we may safely assume that this will, in due course, make a weekly appearance, and doubtless Mr. Biggs will receive the support of the majority of his old friends. Speaking for ourselves, we wish him every success in any new venture he may undertake.

Mr. J. H. Cundall who had the organisation and management of the electric lighting of the Colonial and Indian Exhibition, is now practicing on his own account as an electrical engineer, and has taken offices at 121, Cannon Street, London.

Fiat Justitia.—At the Berkshire Petty Sessions, held at Windsor, on Saturday last, Sir S. A. Blackwood, Secretary of the General Post Office, was fined £1 with 10s. 6d. costs, for having on the "Fourth of June," on the occasion of the Eton celebration, passed in a boat on the Thames, near Windsor, so as to obstruct, impede, or interrupt the College aquatic procession, contrary to one of the bye-laws. The evidence of Lieut. C. E. Bell, Superintendent of the Upper Thames, went to show that the defendant had been spoken to four or five times respecting his conduct and that his replies were very discourteous. But the most curious incident in the affair is that one of the justices who sat upon the bench was Sir Daniel Gooch, of the Telegraph Construction and Maintenance Company, contractors to the Post Office.

Prof. Forbes's Tables.—The tables compiled by Prof. George Forbes, F.R.S., for calculating the size of conductors, have been converted from his Cantor Lectures, of 1885, into international units. He has found that a demand existed, so he has recalculated the tables and rendered them more compact.

Incandescent Lamp Litigation.—A correspondent reminds us that during the next few weeks some important points are likely to be decided as to the validity of certain lamp patents. The following cases are down in the list for trial:—The action of Messrs. Shippey Brothers against the Edison and Swan Company for intimidation of their customers using the "Shippey" low-resistance glow lamp; the application of Mr. Arthur Shippey in the Court of Appeal for a new trial on facts and evidence not produced at the last case; and also the pending action of the Anglo-American Brush Electric Light Corporation against the Edison and Swan Company for alleged infringement of Mr. Lane-Fox's patents.

Electric Light in Naval Operations.—In connection with the series of naval and military operations, which have just been brought to a close at Portsmouth, electricity played a most important part. The attacks on Langston Harbour took place at night, and on the first occasion both sides were provided with electric search lights. The defenders had six, these being under the command of Captain Cardew, R.E. Telephonic communication was established between the opposite shores of the harbour, so that the word of command could be promptly circulated among the troops, but in the course of the hostilities some of the wires were cut by torpedo boats, which had broken through the boom. Telegraphic communication was also established by Major Bennett, R.E., with the garrison at Portsmouth. The submarine mines were controlled from the shore by means of cables. On Friday night the operations were intended particularly to test the efficiency of the electric light in detecting the approach of torpedo boats, steaming at a high rate of speed. Capt. Long, of the torpedo schoolship *Vernon*, was in command of the attacking flotilla of torpedo boats, which were managed with great skill. Varied tactics were tried by the attacking boats, but whether they stealthily crept along the shore in Indian file or made a bold rush into the harbour, which was protected by batteries of quick-firing and machine guns (the latter being represented by musketry), they were quite unable to escape the penetrating glare of the electric search lights, which effectively illuminated the whole neighbourhood, when necessary, for miles around. Baffled in every attempt to pass the batteries unperceived or to approach sufficiently near to discharge his torpedoes, Capt. Long at length ran in his gunboats, which created a deal of smoke, with the object of bedimming the electric rays. In the opinion of the umpires, however, this device also failed, and when the "cease fire" was sounded half an hour after midnight (the fight having lasted three hours) there was a general consensus of opinion that the search lights had triumphed.

Central Station Supply in Liverpool.—The Liverpool Corporation at a special meeting held on Wednesday, brought forward for confirmation the terms of the licence upon which they have agreed with the Liverpool Electric Supply Company (Messrs. Holmes and Vaudrey, engineers) for an application to the Board of Trade. The area specified in this licence includes the business centre of Liverpool and a large portion of the better class residential division of the town. The term of the licence is six years. Electricity is to be supplied by meter, and charged on a sliding scale, varying from 1s. to 4d. per unit, according to the number of hours during which the supply is used annually, that is to say, the first 400 hours of the maximum supply are charged at the rate of 1s. per unit, the next 400 hours at 8d. per unit, any subsequent supply at 4d. per unit. Thus, a customer burning his lamps 1,200 hours per year would pay a sum equal to an average rate of 8d. per unit. This system of charging makes an equitable scale which divides the cost of the light fairly amongst the various classes of users. The Liverpool Electric Supply Company has already constructed two central stations, and a third one is in course of construction. The laying of the necessary underground mains will be proceeded with immediately the formal permission has been obtained from the Board of Trade.

Torpedo Boat for India.—The Abercorn Shipbuilding Company, Paisley, has just received an order from the Indian Government to build and engine a torpedo boat, to be used in the harbour defence of Calcutta. The vessel will be supplied with triple-expansion surface-condensing engines of 900 horse-power. The engines are to drive the vessel at a rate of 23 knots per hour. In addition to these engines, there will also be engines for working torpedo-gearing, electric lighting, forced combustion, air-compressing, air accumulators, and for fresh-water condensing. All the engines will be supplied by Hanna, Donald and Wilson, Paisley.

Technical Papers.—It is almost a circumstance for regret that the first paper to be read before the 1887–88 session of the Society of Telegraph-Engineers and Electricians, is not one on electric lighting or the transmission of power. Our reasons for making this remark will be well understood by the members of the society.

The Cost of Electric Lighting.—Prof. Ewing recently lectured at Dundee on "The Present Position and Prospects of the Electric Lighting Industry," and we presented our readers with an abstract of the lecture. Our excellent contemporary the *Gas World* takes exception, with seemingly no definite reasons, to certain comparisons of cost made by Professor Ewing between gas and electricity in mills. For 1,200 hours' lighting in one of the Dundee mills electricity cost £50 as compared with £82 for gas in the same number of hours. Our contemporary thinks that "from the electrician's point of view this is a satisfactory statement, but possibly, if it were investigated, it would be found that certain elements had been omitted, which, duly considered, would have given it a different complexion." What reason has the *Gas World* for suggesting that Prof. Ewing may have been guilty of a falsehood or a misrepresentation? He has a reputation as a scientist and an electrician, is well known in Dundee, and, as our contemporary remarks "his utterances on this subject attract a good deal of attention." This being the case, it is scarcely likely that he would hazard a statement of the kind if it were demonstrably false; nor would he be likely to make it without having previously assured himself that all the essential "elements" had been calculated. We do not contend for a moment that electric lighting is generally speaking cheaper than gas; but Prof. Ewing has stated that there is one sphere for its application where it is so, and the *Gas World* should take means to discover the truth or falsity of the statement before impugning his accuracy.

Messrs. Ransomes, Sims and Jefferies Engines.—A telegram has just reached Ipswich announcing that at the Charkoff Exhibition (Russia), the highest award, namely, a gold medal, has been awarded to Messrs. Ransomes, Sims and Jefferies for their exhibit.

Modern Views of Electricity.—Perhaps no series of papers ever penned upon electrical theories were ever more worthy of perusal, or have afforded anything more suggestive for the reflective mind to ponder over than Dr. Lodge's "Modern Views of Electricity." We think we are not going beyond the mark in saying that these papers will be as fully appreciated by the professor as by the student.

Electric Street Cars.—No doubt the discussion upon Mr. Reckenzaun's paper, which he recently read before the American Institute of Electrical Engineers, will be found useful to those engaged in developing electric locomotion on this side. In the States both the lecture and discussion created quite a flutter of excitement amongst the electrical fraternity.

NEW COMPANY REGISTERED.

South African Gas Company, Limited.—Capital, £100,000 in £5 shares. Objects: To manufacture and supply gas and light in the Municipality of Woodstock (Cape Town, South Africa) and elsewhere in Cape Colony. To carry on at Woodstock the business of an electric light company in all branches, and to carry on the business of electricians, mechanical engineers, and suppliers of electricity for light, heat, motive power, or otherwise. Signatories (with one share each): J. B. Purchase, 11, Queen Victoria Street, E. H. Stevenson, C.E., 38, Parliament Street; A. D. Doughty, 1, Drapers Gardens; E. K. Purchase, 11, Queen Victoria Street; H. A. Marshall, 15, George Street, E.C.; C. K. Vokins, 85, Gresham Street; T. A. Kelman, 10, Throgmorton Avenue. Directors' qualification, 100 shares, upon which all calls for the time being shall have been fully paid up. Remuneration, £500 for services rendered prior to the general meeting in 1889, and a similar sum in subsequent years with an additional £100 for each 1 per cent. dividend above £6 per cent. and up to £10 per cent. Registered 22nd inst. by John B. Purchase, Mansion House Chambers.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Manchester and District Edison Electric Light Company, Limited.—At a general meeting of this company held at the Memorial Hall, Albert Square, Manchester, on the 5th ult., it was resolved to reduce the capital to £550,000 divided into 50,000 A shares of £9 each, and 10,000 B shares of £10 each, such reduction to be effected by cancelling capital which has been lost or is unrepresented by available assets to the extent of £1 per share upon each of the 20,000 A shares which have been issued and are now outstanding, and by reducing the nominal amount of all the A shares from £10 to £9 per share. It was also resolved that the name of the company be changed to the Manchester Edison-Swan Company, Limited. These resolutions were confirmed on the 3rd inst. and duly registered 13th inst.

By an official letter dated 19th inst. and addressed to Messrs. Needham, Parkinson and Slack, of 10, York Street, Manchester, the Board of Trade has sanctioned the alteration of the name of this company to the Manchester Edison-Swan Company, Limited, as approved by the shareholders of the company at the general meeting referred to above.

Edison's Indian and Colonial Electric Company, Limited.—The final winding up meeting of this company was held on the 10th inst., when an account was laid before the members showing the manner in which the winding up of the company has been conducted and its property disposed of.

Regenerative Electric Light Company, Limited.—The statutory return of this company made up to the 18th inst. was filed on the 20th inst. The nominal capital is £50,000 in £1 shares. 1,407 shares have been allotted, and 5s. per share has been called up. The calls paid amount to £312 10s. and unpaid to £39 5s. Registered office, 7, Westminster Chambers, Victoria Street.

Domestic Battery Company, Limited.—The statutory return of this company made up to the 12th inst. was filed on the 18th inst. The nominal capital is £20,000 in £10 shares. 290 shares have been taken up, 145 being considered fully paid. Upon the remaining shares the full amount has been called up, the calls paid amounting to £1,450 and unpaid to £50, the latter amount being upon five shares forfeited. Registered office, 9, Gracechurch Street, E.C.

Anglo-Portuguese Telephone Company, Limited.—The statutory return of this company made up to the 20th inst. was filed on the 21st inst. The nominal capital is £50,000 in £1 shares, the whole of which have been allotted and are considered as fully paid. 37,500 shares are held by the Edison Gower Bell Telephone Company, Limited, and 12,493 by Mr. J. O'Neill O'Neill, of Lisbon. Registered office, 53, New Broad Street.

Sudworth and Company, Limited.—An agreement of the 29th ult. (filed on the 6th inst.) provides for the purchase by the company of the business of electrical engineers carried on by Charles Krauss Falkenstein and Samuel Sudworth at the Falcon Works, Bentham Road, South Hackney. The purchase consideration being 1,425 preference shares and 575 deferred shares of £1 each.

Akester Electro-Motor and Accumulator Company, Limited.—The statutory return of this company, made up to the 29th ult., was filed on the 11th inst. The nominal capital is £5,000 in £1 shares, the whole of which are allotted; 3,500 shares are considered as fully paid, and 5s. per share has been called upon the remaining 1,500 shares. The calls paid amount to £304 10s. and unpaid to £70 10s. Registered office: 58, Compton Street, Goswell Road.

Electric Car and Power Company, Limited.—An agreement of 6th ult. between the Contract and Agency Corporation of Manchester and J. H. Church, as trustee on behalf of a then intended company, to be called the Electric Motive Power Company, Limited (Jarman's patents), provides for the purchase by the said company of the letters patent No. 2,783, dated February 26th, 1886, granted for improvements in the construction of electro-motors for the propulsion of tramcars, and electric locomotive vehicles, for £1,500 in cash and £40,000 in fully-paid shares. Under the said agreement Mr. R. J. Jarman is to be general manager of the company for seven years at an annual salary of £300 per annum, increasing £100 per annum.

An agreement of October 6th between the Contract and Agency Corporation, Limited, and T. H. Church, on behalf of the Electric Car and Power Company, cites that it is supplemental to the agreement of 6th September between the said parties. It having been pointed out that a quotation for the shares of the company on the London Stock Exchange cannot be obtained if the vendors take more than one-third of the nominal capital of the company in fully-paid shares as part of the purchase-money, it has therefore been agreed that the purchase-money should be paid for as follows, viz., £33,000 in fully-paid shares, and £22,000 in cash. Both these agreements were filed on the 12th inst.

Schanschieff Electric Battery Syndicate, Limited.—The registered office of this company is now situate at 65 and 66, Basinghall Street, E.C.

CITY NOTES, REPORTS, MEETINGS, &c.

The Eastern Extension, Australasian, and China Telegraph Company, Limited.

THE twenty-eighth ordinary general meeting of this company was held on Wednesday afternoon at Winchester House, Old Broad Street, E.C. Mr. John Pender, chairman of the board of directors, presided over a small number of shareholders. The report appeared in last week's issue.

The Chairman said the gross receipts for the last half year were £219,201 as against £224,843 in the corresponding period of 1886, or a decrease of £5,642. This result, however, was not unsatisfactory, having regard to the fact that in the corresponding period the reduced tariffs had not come into operation. The reductions agreed to at Berlin were, however, based on the figures of 1884 and 1885, which were the best years the company had ever had; and although they this year carried a larger number of words than in 1884 they would only have made up £18,000 of the loss of £50,000 per annum which it was estimated would result from the reduced tariffs, leaving over £30,000 still to be recouped. As the traffic was increasing this loss would doubtless be made up in the course of time, but their experience showed that the traffic did not respond so readily or so rapidly as the advocates of low tariffs would have them believe, for they found that customers were as particular in dealing with pence as with shillings, even in sending an ordinary telegram. The expenditure for the last half year was £76,241 as against £81,775 for the corresponding period of 1886, showing a decrease of £5,534. This was due to their having disposed of their screw-steamer *Agnes*, and consequently having only two ships as against three in the corresponding period of 1886. The nett revenue was £97,662 as against £97,480 in the corresponding period of 1886, showing a decrease of £182. Their quarterly interim dividend of 1¼ per cent. had been paid during the half year, and another of like amount had been distributed on the 15th inst., leaving £35,162 to be carried forward to the current half year, at the end of which the distribution of bonus and the sum to be carried to the reserve fund would then be dealt with. During the last week he had received six letters from shareholders. One of them, a gentleman, complained of non-payment of bonus. When they started the payment of bonuses, it was understood that the bonus was to be paid as the result of the year's working. They were pressed at one time by some of their shareholders in 1884 and 1885, these being the good years, to pay the bonus half-yearly. They agreed to pay the bonus then half-yearly, but last year after the reductions to which they had had to submit at Berlin, they had thought it more desirable to postpone it. In fact, they could not pay the bonus the first half-year, but as he had intimated, no doubt by the end of the year they would be able to pay a portion of the bonus. The directors were precisely in the same position to-day as they were then. They thought it desirable to maintain the payment of the bonus at the end of the year. He believed they would be able to carry out the promise they had made; it would be paid whether it were 1 per cent. or more. The accounts at the end of the year no doubt would justify the directors in paying what amount they thought desirable. Another shareholder, a lady, also asked why the bonus was not paid. She had overlooked last year, and had simply referred to the times when they were getting the bonus at the half-year. In short, out of the 5,000 shareholders the company had, they had only had six letters on the subject. All these letters had been answered, and he hoped in a way satisfactory to the writers. There had been no serious interruptions to their system during the past half-year. The Tonkin and Hong Kong cables were now in good working order. Since the close of the half-year under review a further portion of the Singapore-Saigon section, which was the only cable not duplicated, had been renewed with brass ribbon cable to the length of 174 nautical miles, leaving 150 to be renewed. This would probably be completed during the current half-year, in which case the cost of the operation would be shown in the next published accounts. On this question of renewal of cables, he would like to refer to the very important question which was so often referred to a few years previously. They had found constant cause for repair owing to the action of the little insect the teredo. Of course, brains were set to work, and the result had been that they had entirely counteracted it. It might interest the shareholders to know the result of the operations in that direction. He might mention that the brass ribbon cable was a thin film of brass ribbon which covered part of the cable, and when the teredo came to that it seemed to die. Heretofore it had been able to get through the interstices of the cable to the gutta-percha, and the consequent result had been a fault. No less than 194 faults had been renewed in 11 years, or an average of 18 a year. Now, however, during the last six years, since the brass ribbon had been used there had only been four breaks, and these were entirely due to ships' anchors. Consequently their experience, extending over a period of nearly seven years, showed that it had successfully resisted the attacks of the teredo. They would have observed from the report that they had removed their hulk stationed at Singapore, and the whole machinery on board. They had increased their number of tanks there and had got a thoroughly efficient place for a cable depôt, both for cutting such an amount of cable as might be required in a great emergency, and also for re-serving purposes. When he last addressed them he had gone very fully into detail as to their relations with the Australian colonies, and also with New Zealand. He had only to say that day that during the last six months, since the return of the delegates to their respective homes and Governments, nothing had been done. They had submitted a proposition to the Colonial Governments which if they accepted he believed would materially reduce the present tariffs to those places. and would make the property which the shareholders held in the company much more valuable, because it would rest upon a guarantee from the Colonial Governments. He believed at the end of next month a a conference would be held at Adelaide to consider the question of cheaper postal rates, and also telegraph rates, betwixt the mother country and the colonies. Until, however, they heard the decision come to by that conference, their policy was simply to leave things alone. They were pretty well satisfied with the progress of their business at the present time, and were ready to meet the requirements of the colony provided they agreed to their terms. He had also at the meeting to which he had referred spoken of their relations with New Zealand. Since that time there had been in that country a dissolution of Parliament. A new Parliament had been elected and a new Ministry had been formed. The Government they differed with was now out of office. They were giving the new Government a little time to settle, but so soon as they were settled down they would resume their correspondence, and he thought with a fair prospect of success. They had also during the last six months been in close negotiation with the Chinese authorities. The result of the negotiations would be to place this company in a very satisfactory position with the Chinese Government. They had endeavoured to show that Government that submarine telegraphs were a great necessity for China. They, however, said that land lines might beat the submarine system; but the result had been that they had come to a fair understanding by which both interests would be fairly and properly protected. The points in the agreement were settled; it simply wanted the approval of the Chinese Foreign Office, and that they were daily looking for. He had said, and he said again, that that once settled, for the next 16 years they would be able to look to China and the growth of the China trade without any fear of undue competition. He might mention that now nearly the whole of their system was duplicated; he might say almost triplicated, because in nearly all the system they were in a position to work the duplex, so that so far as efficiency was concerned they were in the most efficient state that a submarine telegraph company could be. They were still short of 154 miles to complete their Saigon system with a brass tape cable. Their relations with the Government they always desired to be as cordial as possible, and they had felt this had not been a bad policy. The other day the Government who had laid down a cable at Port Hamilton had found that it was useless and unnecessary. The company had taken the opportunity of taking it off their hands at a price which would enable them to lay it down between Singapore and Saigon, and that operation was, he might tell them, quite satisfactory to the Government, and he had no doubt the company were equally satisfied with their bargain. He thought he had now gone over all the points necessary to go over. There was nothing at the present moment which was going on that he had to tell them about; and he might conclude by saying that their relations with foreign Governments were very satisfactory, and that their revenue was increasing also in a satisfactory degree. He thought by the time he had the pleasure of meeting them six months hence he would be able to say that there had been considerable progress during the past half-year, and that they would resume the bonus system. He moved that the accounts be received and adopted.

The Marquis of Tweeddale seconded the motion, which was carried unanimously.

On the motion of a Shareholder, a hearty vote of thanks to the chairman and the board of directors was carried with "clapping of hands."

The Chairman, in responding, thanked them on behalf of his colleagues and also for himself. He had stated, he said, very fairly, though it might have been at greater length, exactly the position of the company at the present time, and he thought that considering the dividend they had paid, and the prospects of the company, they had reason to congratulate one another on the position they held. He believed that they now commanded the confidence, not only of the telegraphing companies, but also of the investing public. As long as they commanded these two he thought they would satisfy their shareholders.

The meeting then terminated.

The Brazilian Submarine Telegraph Company, Limited.

THE report of the directors for the half-year ended June 30th states that the revenue for this period amounted to £100,876 7s. 6d., and the working expenses to £13,262 2s. 10d. After providing £14,205 0s. 0d., for debenture interest and sinking funds, and £2,004 17s. 6d. for income tax, there remains a balance of £71,404 7s. 2d.; to this is added £7,528 5s. 1d. brought forward from December 31st last, making a total of £78,932 12s. 3d. A quarterly interim dividend amounting to £19,500 has been paid, and £25,000 transferred to the reserve fund, leaving a balance of £34,432 12s. 3d.

The directors now recommend the declaration of a final dividend of 3s., per share, making, with the interim dividends, a total dividend of 6 per cent. for the year, and also the payment of a bonus of 2s. per share, both free of income tax, which together

will amount to £32,500, being a distribution in the aggregate of 7 per cent. for the past year, leaving a balance of £1,932 12s. 3d. to be carried forward.

On July 30th last, the sum of £37,100 was transferred from the sinking fund to pay off the 371 bonds of the 1884 issue, drawn for redemption in April last. This repayment reduces the debenture debt to £187,900.

The various sections of the company's line are in good working order.

Indo-European Telegraph Company, Limited.—The directors have declared an interim dividend for the half year ended June 30th last, at the rate of 5 per cent. per annum, free of income-tax, payable on and after November 1st.

The West India and Panama Telegraph Company.—At the approaching meeting of this company the directors will recommend a dividend of 9s. per share on account of arrears of dividend on the first preference shares.

TRAFFIC RECEIPTS.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending October 21st were £3,316, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1886.

7636. "Improvements in the preparation or manufacture of negative elements for voltaic batteries." D. G. FITZ-GERALD. Dated June 7. 6d. Claims:—1. The process of producing granular peroxide of lead, or partially peroxidised granules of lead compound, which process consists in granulating a plastic mixture composed of litharge (or its equivalent) and a solution of a salt or an acid which slowly reacts upon the lead compound and causes it to "set" whilst the granulating operation is being effected, and subsequently more or less completely converting the granulated substance into peroxide of lead by the agency of chlorine, or of electrolysis, or by both these agencies. 2. The process of manufacturing negative elements for voltaic batteries, which process consists in incorporating granular peroxide of lead or peroxidised granules of lead compound (obtained by the action of electrolysis, or of chlorine, or by both these agencies combined, upon a mass mainly composed of the monoxide of lead which has been granulated and caused to "set" as herein described) with a plastic mass composed of monoxide of lead in admixture with the solution of a salt or an acid which will cause the mass to "set," or with glycerine, or a solution of glycerine in water. 3. The use in combination with and surrounding an element of carbon, platinum, or "lithanode," of the granular peroxide of lead, or partially peroxidised granules of lead compound as a depolarising agent, the same being contained within a porous, perforated, or reticulated vessel or partition.

8412. "Improvements in apparatus for ransferring cash from one part to another part of a shop or other building and for similar purposes." H. H. LAKE. (Communicated from abroad by the Kenney Electrical Cash Carrier Company, of America). Dated June 25. 8d. Relates to a cash system, or apparatus for taking money from attendants or clerks stationed at different parts of a store to the cashier's desk, and returning the change from the cashier's desk to each of the clerks from whom the money was originally received. The claims are 10 in number.

8573. "Improvements in portable electrical batteries and appliances in connection therewith." J. T. ARMSTRONG. Dated June 30. 11d. Claims:—1. The application and use of complete itinerating electrical apparatus, mounted, fitted, and arranged upon wheels for transport or transference to any distance or locality, for at once producing the electric light or power when and where required, substantially as described and illustrated on the drawings. 2. The application and use of apparatus for transport as aforesaid, and also for charging accumulators or secondary batteries, substantially as described and illustrated on the drawings. 3. The application and use of apparatus as aforesaid, fitted with portions of the apparatus for reducing weight, and arranged to receive supplies of fluids at convenient stations, substantially as described. 4. In electrical batteries, the application and use of cisterns made of glass or other suitable material fitted with plugs and other outlets, substantiallly as described and illustrated on the drawings. 5. The use of the itinerants as described for the purpose of supplying fixed secondary batteries with electricity for lighting and motive power, or either of them. 6. The general combinations, arrangements, and applications of the several and respective parts constituting the improvements in road vehicles and portable electrical batteries and appliances in connection therewith, substantially as and for the purposes described.

8842. "Plates without support, entirely made of active material, for voltaic batteries." E. ANDREOLI. Dated July 6. 8d. Relates chiefly to the production by means of chemical and metallurgical methods of dense homogeneous, conductive and coherent plates, blocks, cylinders and rods which are converted afterwards into negative and positive electrodes for secondary and primary batteries, each of which plates being a solid mass of active material without support of any kind, *i.e.*, consisting entirely on one side of porous lead or other metal, and on the other of its peroxide. The claims are 4 in number.

9016. "Improved apparatus for measuring the efficiency of an electric circuit." Sir WILLIAM THOMSON. Dated July 10. 3s. 4d. This apparatus consists of an inspectional magneto-static current meter used in connection with adjustable resistance coils, and an electro-dynamic balance, with electrolytic apparatus for determining its constant, by which the coefficient of the current meter, varying as it does from time to time, is at any time determined in terms of constant units. The magneto-static current meter consists of a suspended magnet, preferably a thin circular disc of steel, suspended by a silk fibre so as to be in the centre of the field of a double electro-magnetic coil so arranged as to give, as nearly as may be, an uniform magnetic field in its centre. The controlling magnets are adjustably fixed in an iron sheath enclosing the electro-magnetic coil, and their distances from the centre of the field are adjusted, and varied, if need be, from time to time, to give any convenient value to the co-efficient, according to comparison with the electro-dynamic balance. The indicator of deflections of the suspended magnet may be either a non-magnetic needle pointing to divisions on an adjustable tangent scale, or a ray of light reflected from a mirror, and it may be either wholly outside the iron sheath, or it may project from the inside to the outside transversing a horizontal slot in the sheath. The upper end of the fibre is attached to a spring yielding so freely to a downward pull that before the fibre can be broken, the suspended magnet and attached needle or mirror reaches the bottom of its range. The electro-dynamic balance consists of a piece of soft iron, or a movable coil made temporarily magnetic in virtue of the current to be measured, and actuated by the electro-magnetic force of a fixed coil or coils through which the current passes. The piece of soft iron may be suspended on a gravity balance, and actuated in the manner described in the specification of the said Sir William Thomson, No. 11,106, A.D. 1884, but for sea use it is preferred to make it in the shape of an oblate spheroid, and to suspend it on a stretched elastic wire. Its tendency to turn its equatorial plane to parallelism with the lines of force of the fixed coil or coils, balanced by the torsion of the wire after the manner of a Coulomb's torsion balance, shows the strength of the current to be measured. For land use a movable coil and a gravity balance with a trunnion to prevent horizontal motion of the axis of the balance is preferred, and with decimal arrangements for putting on and taking off the weights. The resistance coils are of wire, preferably platinoid, wound on metal drums or cores, preferably copper coated with thin insulating material such as varnished paper, so that the heat generated by the current may be carried away, whether by emission to air or by aid of a stream of water, across the uncoated parts of the surface of the core. The coils are either each separately movable—and are placed in combination, in series or in multiple arc, by stout metal terminals dipping into cups of mercury—or they are connected by means of copper spring wedges between fixed terminals of the coils and fixed studs of copper. To adjust the resistance continuously to any desired amount, an improved form of Wheatstone's rheostat is used, in which the wire is guided from one cylinder to the other by a fork carried along through the requisite range by a nut travelling on a long screw shaft. This screw shaft carries a toothed wheel which turns the two cylinders by means of toothed wheels attached to their shafts, a watch spring, as in Joulin's improvement of Wheatstone's rheostat, keeps the wire always tightened to the proper degree. A leather buffer at each end of the range of the nut acts as a guard against overwinding in either direction. The current of the circuit is divided into two branches, one of them a known high resistance in circuit with the magneto-static current meter, and the other through the electrolytic vessel, the electro-dynamic balance, and a resistance continuously regulated by the rheostat. The rheostat is worked by hand so as to keep the current as indicated by the electro-dynamic balance very accurately constant during a certain time—an hour, for example—and the quantity of copper deposited or dissolved during that time in the electrolytic vessel is determined by accurate weighing. Thus, according to the known electro-chemical equivalent of copper, the strength of the current is calculated in absolute units; and from it the coefficient of the magneto-static current meter, and the constant of the electro-dynamic balance are determined. In continued use of the apparatus on an electric lighting circuit, the working circuit of the lights takes the place of the regulating by rheostat. The electro-dynamic balance shows the strength of the current at any time by the proper adjustment of its weights; the electrolytic appliance shows the whole quantity of current that has passed in any time, and the magneto-static current meter shows the potential of the circuit. The claims are 18 in number.

9478. "Improvements in dynamo-electric machines." J. A. FLEMING. Dated July 21. 8d. Claims:—1. In dynamo-electric machines field magnets having coils wound in sections reversely to the principal magnetising coil or coils and connected to a commutator or divided contact arc over which moves a contact piece actuated by a governor or speed indicator, or the like, substantially as and for the purpose described. 2. In connection with dynamo-electric machines charging a secondary battery an electro-magnetic relay

in combination with a governor or speed indicator or the like so operated by current from the secondary battery as that when the speed of the dynamo-electric machine diminishes to a predetermined degree back current from the secondary battery is prevented from flowing through the armature coils of the dynamo-electric machine. 3. In connection with a rotating portion of a dynamo-electric machine an arrangement of contact makers and friction gearing or slipping belt or the like for permitting the direction of rotation of the machines to be reversed without reversing the direction of the outward current, substantially as pescribed and illustrated by the diagrams.

11179. "Improvements in the application of electricity to spectacle frames." J. T. LEIGHTON. Dated September 2. 8d. Consists of providing two plates, discs, or pieces of metal, one of copper, and one of zinc, or any other two metals, one of which shall be electro-positive to the other. The plates or discs above mentioned, are attached to the bridge or nose-piece of the frame in such a manner and position, as to be capable of free adjustment, or be removed altogether if required, and so as to rest comfortably upon either side of the nose of the wearer. The metal plates or discs are electrically connected by the bridge or nose-piece itself, or independently by means of a platinum or copper wire, or other suitable metallic conductor; a groove being provided in the bridge or nose-piece for receiving said wire or conductor; or the wire may be coiled round the bridge or nose-piece, thus converting the bridge into an electro-magnet, in which case the wire aforesaid would be insulated with silk, or other suitable insulating material. There is 1 claim.

12065. "Improvements in electrical telephones." R. THEILER. Dated September 22. 8d. Relates to the apparatus described in the No. of the REVIEW for last week. The claims are 3 in number.

CORRESPONDENCE.

The Water Primary Battery.

The following letter has been sent to us respecting the so-called libel suit with which we have been threatened :—

[COPY.]

"Gresham House, Old Broad Street,
"London, E.C., 22*nd October*, 1887.

"Gentlemen,—In answer to your last letter our client, Mr. D'Humy, complains of a letter inserted in your paper on the 23rd September last, signed "R. E. Crompton," wherein it is implied that the report of Mr. D. Monnier (of which we enclose a print) was never made, and, in fact, that our client was publishing a document that never was in existence, and by your editorial comment at the foot of such letter, and also at the foot of the letter written by our client and inserted in your paper of the 30th September you undoubtedly sanction such statements. We must ask you in your next issue to retract such statements, and, if you wish, before so doing you can inspect the original of Mr. D. Monnier's report dated 1st July, 1884.

"W. H. SMITH & SON.

"To the Proprietors, &c., ELECTRICAL REVIEW."

57, Rue Pizalle, Paris,
Monsieur R. D'Humy. 1*st July*, 1884.

Dear Sir,—I continue every day the experiments on your battery; the results already obtained appearing interesting enough to induce me to prolong these trials, less from a practical point of view than the chemical theory of this battery, which is worth studying thoroughly.

I consider it as susceptible of forming a practical and economical solution of the problem of domestic lighting, and I cannot urge you too strongly to prepare the basis of a company for the working of this battery.

As I have already told you, I think you should get the capital necessary for the fabrication and sale of the cells, with a working capital sufficient to enable you to keep in order the cells sold, in case the purchasers do not wish to do so themselves.

I feel persuaded that as soon as the company is constituted and advertised, the number of applications that you will receive will be very considerable. The capital of the company being almost exclusively reserved for the creation of a stock of goods need not be considerable to realise important profits resulting from the difference between the cost price of the cells and their sale price.

I have such confidence in the success of an enterprise established on the basis that I have pointed out to you, that I shall be very happy to take a part of the capital, either for myself or my friends.

I shall be very pleased to talk with you on this question as soon as you return to Paris, for it is necessary to form the company for working it without delay, so as to profit entirely by the demands which will not fail to be made in the autumn; it is, as you know, the time when everyone occupies himself with the lighting question.

Awaiting the pleasure of seeing you,

I remain, yours very sincerely,
(Signed) D. MONNIER, E.E.

[We confess our inability to place the same construction on Mr. Crompton's letter and our editorial comments, as that attributed to them by Mr. D'Humy's solicitors. The extract which accompanied the above communication, and to which M. Monnier's name is attached, was published with the Water Primary Battery Company's prospectus, *and referred to in our issue of September 9th*, but as it is dated over three years ago, its utility does not, in the present day, seem very apparent. Perhaps Mr. Crompton or his friend would like to favour us with some further explanation. —EDS. ELEC. REV.]

Copper Wire.

Before Mr. Morgan Brooks decided that a fallacy underlaid Mr. Preece's calculations, it would have been well to have given some credit for practical knowledge of wire running in this country, and to have assumed that a reason existed for the data on which these calculations were based.

It was decided that under normal changes of temperature the strain on a given wire should not exceed one-fourth its breaking strain, and in order that this result should be achieved it was necessary to start with a maximum strain of one-fourth at lowest temperature and to calculate upwards. By reversing the process, as is evident to all, and as is shown by Mr. Brooks himself, it is only by drawing on the reserve of elastic strength of the wire itself that the latter is prevented from breaking. His own tables show that under varying conditions of span the strains at the lowest temperature reach from one-third to two-thirds the ultimate breaking strain of the conductor. Now, if provision had only to be made for the normal lowering of temperature, a wire under such conditions might be fairly safe, although to allow of such a small reserve of strength as is indicated by straining a wire to two-thirds of its breaking strain, offends against the ordinary engineering canons. But in Great Britain regard has to be paid to the not unfrequent falls of snow of a wet adherent character, which freezing on to a wire increases its diameter to one, two, or three inches, and its weight from 10 to 30 times. Without a large reserve of elasticity to draw upon, wires under such circumstances will simply be torn down in all directions; whereas if sufficient elasticity exists, the accumulation may increase to a very considerable extent without the terminal strain exceeding one-third to one-half the breaking strain. Hence the desire not to draw on the reserve of strength due to the elasticity of the wire, but to leave that to meet snowfalls of the character referred to. It would even be desirable to increase the sag and diminish the initial strains to a greater degree than is shown in the tables, if this were possible, so as to provide a wider margin of safety; but, unfortunately, practical reasons preclude this, as any material increase in the sag leads to wind contacts.

Doubtless in America, the climatic conditions are widely different from those in this country; hence precautions which are desirable here may be unnecessary there.

Obviously if a wire be drawn up tightly in summer, and it is only saved from breaking in winter by its elasticity, the difference in sag at extremes of temperature will be much less than under the conditions assumed in Mr. Preece's tables, so that American observations of an empirical character on wires strained to an abnormal degree in summer do not vitiate the accuracy of tables drawn up for a different condition of things.

J. Gavey.

October 20th, 1887.

Secondary Batteries.

I am glad to learn that Mr. Reckenzaun sympathises with my work in connection with secondary batteries, and assure that gentleman in return that I have also followed his strenuous efforts for the advancement of accumulators with great interest, and that I wish him the success which he so richly deserves.

If, however, Mr. Reckenzaun calls my patent of 1884 "mysterious," I can only account for it by presuming that he has not found sufficient time to peruse it, else I think he would have arrived at the conclusion that it specifies in a clear manner a definite process for constructing secondary batteries, which anticipates his own invention.

Any of your readers interested in the subject can form their own opinion by comparing the two patents, mine of 1884 bearing the number 9,195.

That I did construct batteries according to the method as described in my patent can be proved by a large number of witnesses.

I can assure Mr. Reckenzaun that I have succeeded in producing a first-rate storage battery (without copying other's work), and I need, therefore, not be reluctant to accept his congratulations, for which I thank him.

Epstein.

Martinikenfelde, *October 21st*, 1887.

Reckenzaun's Battery.

In your article on "Reckenzaun's secondary battery," contained in the number of the REVIEW for September 2nd, which, owing to absence on the Continent, I have only just seen, you state that "this invention of Mr. Reckenzaun is to all intents and purposes identical with" mine.

Allow me to point out that whilst the mode of casting the plates is the same in both inventions the material contained therein is essentially different. In my plates this material is "the hardening mixture of oxide of lead and sulphuric acid, for which letters patent were granted to me in 1882 (No. 4,303)," whilst in Mr. Reckenzaun's plates it is "spongy or finely divided lead or other suitable material possessing the requisite porosity."

Mr. Reckenzaun has assured me that he does not use my material.

E. Frankland.

October 22nd, 1887.

The Proposed Electrical Association.

I have read with much interest the correspondence which has appeared on the subject of the proposed formation of an industrial association, as I recognise the necessity for combined action in regard to various matters of common interest to electrical firms.

A review of the correspondence, however, shows that while there is a general unanimity as to the desirability of an association of some kind being formed, there appears to be some divergence of opinion as to the precise objects and scope of the proposed institution. For this reason I agree with the suggestion which has been made that an outline scheme should be formulated for discussion at a public meeting.

If the association is to be successful, and to possess the confidence of all sections of the trade, it is important that the objects to be attained should be clearly defined, and that the views of all should be adequately and fairly considered. As the representatives of the technical Press possess by far the best means of ascertaining the views of the trade, there would be many advantages in their undertaking the initial work of drawing up a draft constitution, and I hope they can be prevailed upon to do this.

For my own part, I fail to see that the objects of the association can be very numerous, if, as seems to be generally granted, the provinces of the existing societies are not to be encroached upon. That there is important and pressing work for the association to do cannot be denied, and if only a few of the many points suggested by Mr. Rawson are to be energetically pursued, the need for a representative body is apparent. But the association should confine itself to matters requiring united action (*e.g.*, completing the work already commenced of securing a satisfactory amendment of the Electric Lighting Act, &c.), and should not, by attempting to do impossible things, interfere with the natural growth and development of the industry. Such complex matters as "the maintenance of prices at a fair level," which are determined by the economic conditions of supply and demand, cannot well be settled by a resolution of a council, and had better be left to the operation of fair and legitimate competition.

E. Garcke.

October 24th, 1887.

Single Needle Duplexing.

In reply to "A Subscriber's" enquiry in your issue of 21st inst. I have pleasure in stating that the duplex single needle working introduced by me between Glasgow and Carlisle has proved a complete success. It has been used on every occasion on which the work between the two stations required a double service, and has enabled the company to do without the second wire which would otherwise have had to be erected.

And. S. Dunn.

October 25th, 1887.

The Working of Arc Lamps.

In view of the correspondence that has just come to a close on "the causes of unsteadiness in arc lamps" between Messrs. de Wolffers and Lever, instead of so much stress being put on the lamps and the carbons used, would it not be better to bear more in mind Mr. Swinburne's other condition, viz., the "working of the dynamo?"

Mr. de Wolffers has a poor opinion of clutch lamps and American carbons (common), Mr. Lever holds the opposite view.

Now it is well known that the splendid arc lamp installation at the American Exhibition at Earl's Court are Thomson-Houston lamps, and are all *clutch lamps*. Being a resident in the neighbourhood, I have from a field adjoining the exhibition night after night overlooked the installation in the grounds, where I have been able to see about 26 lamps simultaneously. The way those lamps burn has simply made me wonder how any arc light installation could be made so perfect. It is even impossible to detect any flickering when the carbons feed. On no occasion have I seen the common sight of one lamp burning with a dazzling brilliancy, another one giving half the light, or a third hardly any light at all. No; not a lamp differs in this respect, every one giving a uniform, never-varying light throughout. One would have thought that, at any rate, carbons of the best quality are used; but no, they are of the common American kind, the + carbon *not being even cored*. So Mr. Lever is most terse in his query as to whether Messrs. Laing, Wharton and Down think the American carbons "trash"?

I have often thought I should like to see those beautifully scientifically constructed lamps, viz., the Brush, running from a Thomson-Houston dynamo. I imagine they would work much more steadily than they do at present. I cannot help thinking, therefore, that it is not so much the lamp and the carbons as the dynamo with its constant current. I have no interest in any arc lamp or any system, and can therefore speak without any prejudice whatever. It requires no technical knowledge, either, to say the above; the use of one's eyes being alone necessary.

J. S. Ross.

October 25th, 1887.